AGRICULTURAL ENGINEERING

NOVEMBER • 1955

In this Issue . . .

How Oscillation of Tillage Implement Parts Reduces Draft Requirements

•

Recent Watershed Developments Hastened by Cooperative Effort

•

The Application of Hydraulic Drives to Industrial Mowers

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The Evaluation of Secondary Stresses in Rigid-Joint Trusses

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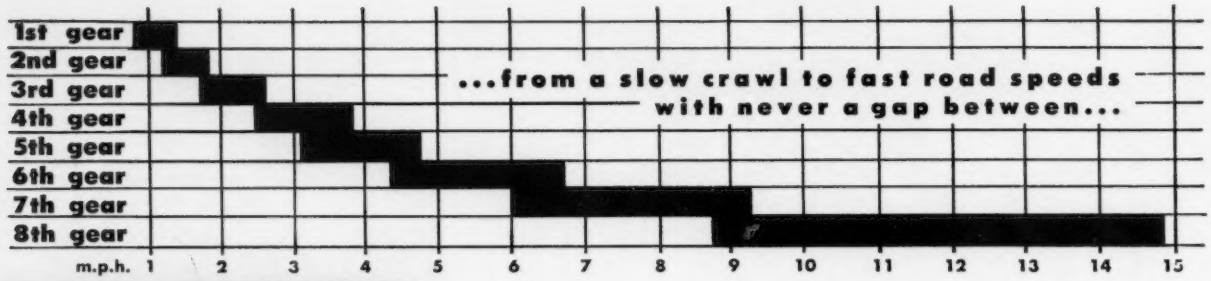
Essential Design Factors for Ponds for Storing Irrigation Water

ASAE Winter Meeting • Chicago, Ill., December 12 to 14

THE JOURNAL OF THE
AMERICAN SOCIETY OF AGRICULTURAL ENGINEERS


1st gear
2nd gear
3rd gear
4th gear
5th gear
6th gear
7th gear
8th gear
m.p.h. 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
...from a slow crawl to fast road speeds
with never a gap between...

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Powr-Range Transmission

Today's Finest Tractor in the 50 h.p. class

All the rewards of persevering research are reflected in the efficiency and simplicity of the new Case Powr-Range Transmission. With only one shift lever and one foot clutch, shifting is quick and easy into any of eight forward gears including two smooth, steady creepers and two reverse . . . all arranged in an amazingly "natural" shift pattern. There's also an unbroken span of speeds, shown in the chart above, that perfectly matches the most favorable speed range of the engine. If conditions slow the engine down to maximum torque, there's always another gear in which to pull the load at the same ground speed at which it was working . . . or even faster. The all-new Case "400" has a multitude of other features that make this 4-plow tractor a symbol of achievement in engineering . . . modern design . . . and the conversion of power into performance that sets new standards of excellence.

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AGRICULTURAL ENGINEERING

Established 1920

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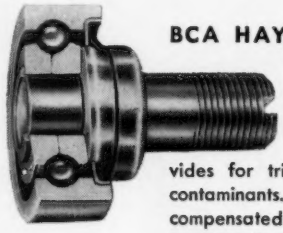
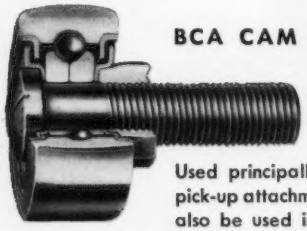
Now, farm implement manufacturers can make the most of the many advantages of ball bearings. BCA Agricultural Bearings are designed to simplify installation problems, reduce maintenance, and bring ball bearing costs down to practical levels. BCA pre-lubricated *package units* combine bearing, housing, and an effective seal in a single, rugged unit—built to cope with the loads, speeds, and operating conditions encountered in agricultural service.



BCA HAY RAKE BEARINGS

Ease of installation and design efficiency of this low-cost *package unit* has attracted wide attention. Patented design provides for triple barrier against entrance of contaminants. Misalignment of tine bar can be compensated for without detrimental effect to bearing. Proved in actual applications—in all kinds of weather, under all soil conditions. Shank length, diameter, and thread can be varied to fit specific requirements.

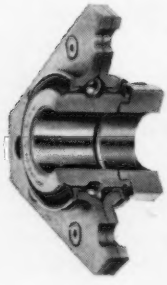


BCA CAM FOLLOWERS

Package unit includes pre-lubricated bearing, seals, cam roller, and mounting stud—all assembled, ready to install. Used principally in hay balers, or whenever pick-up attachments are adopted. Bearing may also be used in roller type conveyors. Thick-sectioned outer race is case hardened to withstand shock, and is slightly convex to assure better contact with cam.

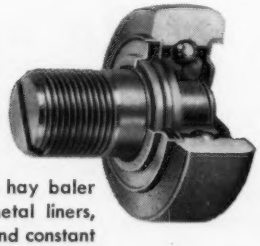
BCA IDLER PULLEY ASSEMBLIES

Pulley, bearing, and seal—all in one complete *package unit*. Pre-lubricated bearing effectively sealed against dust and grit. Simple, rugged construction eliminates frequent field servicing. Adaptable to many agricultural applications, including: combines, forage harvesters, corn pickers, hay balers, grain elevators, cotton pickers. Idler design can be varied for use with flat belts, V-belts or chains.



BCA FLANGE BEARINGS

These simple, low-cost, pre-lubricated *package units* are sealed against water, dust, and dirt. Bearings are simply and economically mounted on commercial shafts. Flange is easily bolted to the equipment. A twist of the eccentric ring locks the bearing to shaft without need for machining the shaft. Built to give dependable service under the most severe agricultural operating conditions.



BCA PLUNGER ROLLERS

Built with a thick-sectioned outer ring, hardened throughout, these *package units* are specially adapted for sliding heavy masses on rails. Principal application is in hay baler plungers, replacing plastic and metal liners, and ending the problem of wear and constant replacement. Bearings come in two types: for flat tracks, and for V-shaped tracks.

If you've got a bearing problem, contact:

BEARINGS COMPANY OF AMERICA

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Pioneers of pre-lubricated *package unit* ball bearings for agriculture

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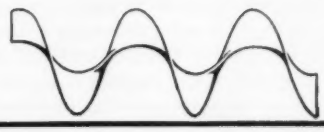
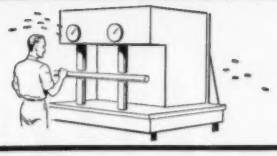
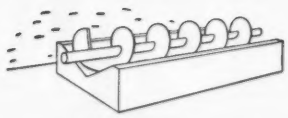
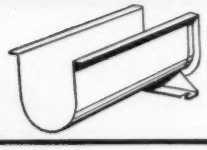
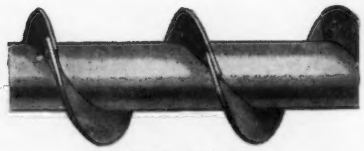
LINK-BELT gives you all these performance extras

ONE-PIECE HELICOID FLIGHTING		Continuous flighting has greater smoothness and strength. Link-Belt also builds many different types to meet your special needs—cut flight, short pitch, ribbon flight, tapered flight, double flight to name a few.
UNIFORM PITCH		Consistent, accurately-formed flighting is produced by specialized modern machinery.
STEELS THAT MEET OUR SPECIFICATIONS		Selected steel for flighting, assures a uniform, smooth, accurately rolled product.
STRAIGHTNESS		Straightness of the completed auger is checked before shipping. Extra care is taken in handling and loading.
ALL COMPONENTS		A full line of related equipment can be supplied by Link-Belt specially engineered for your requirements. This includes troughs, spouts, hangers, drives.

Typical examples of LINK-BELT AUGERS



Sectional-flight

Helicoid flight with plain beater

Helicoid flight

Unmounted Helicoid flighting

Opposed flights with center saw-tooth beater

These are only a few of the many important performance extras you get with Link-Belt augers. Ask your nearest Link-Belt office for 92-page Data Book 2289.

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ORIGINAL

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Auto-Lite is a complete line—featuring sensational new Neosheath Spark Plug Wire Sets that keep plugs dry, famous Flextrand Primary Wire that is easier to install, Auto-Lite Battery Cable with the new anti-corrode Power-Line Terminal. Auto-Lite Cable Products are original factory equipment on leading makes of tractors, trucks and farm equipment.

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Above: On this John Deere Corn Picker, ¾-in. pitch Diamond Roller Chain is used for main power drives and for the two main conveyor drives.

At Left: Diamond Roller Chains help add to long-life high-output operation of the John Deere Beet Harvester. Standard and Extended Pitch Roller Chains serve this equipment.

DIAMOND ROLLER CHAINS
Add Dependability of Operation!

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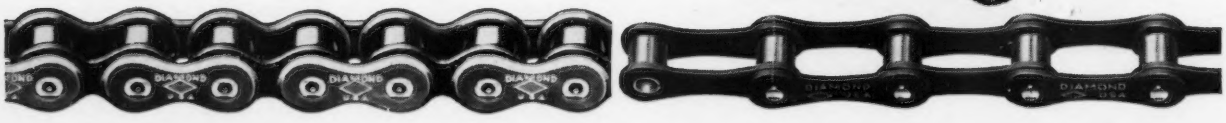

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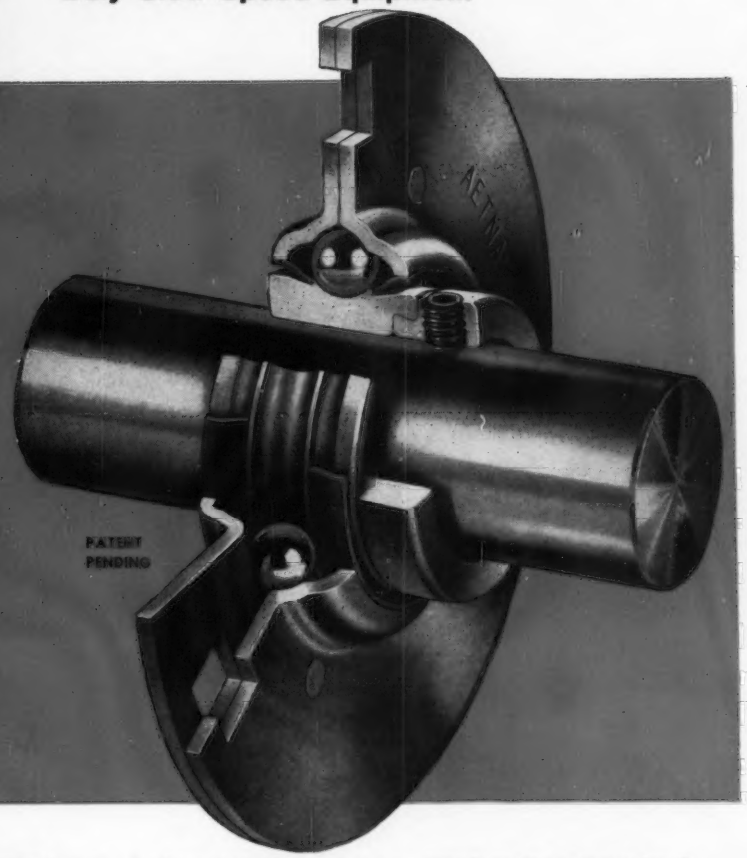
A Complete, Single-Package Ball Bearing Unit That Brings Low-Cost, Anti-Friction Efficiency Within The Range Of All Light-Duty Slow-Speed Equipment



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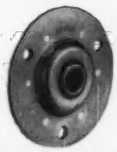
Sprocket Idler Unit

Belt Idler Unit


Grain Drill Unit

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Aetna

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MISCELLANEOUS PARTS

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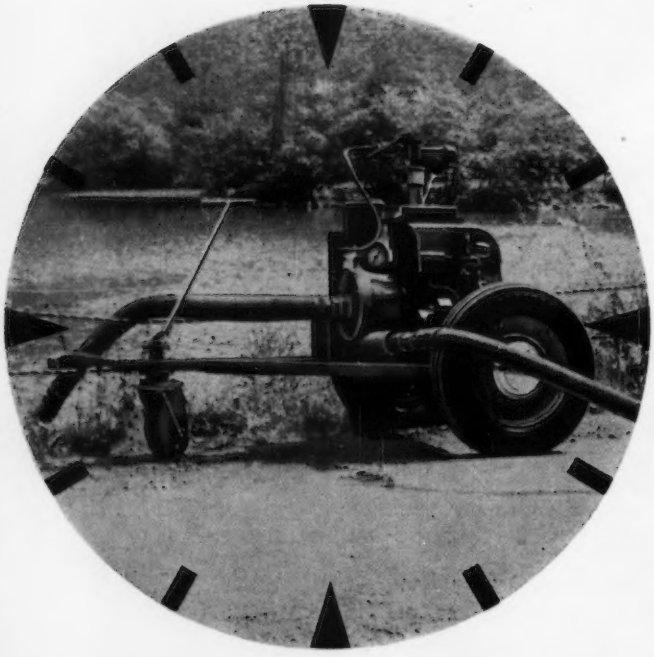

RUN FOR MORE THAN 1,600 CONTINUOUS HOURS! In Williamsport, Pa., this C2-90 was test-run in an actual pumping application for more than 1,600 hours continuously, without overhaul or any service except gas and oil. The engine is still in active service as a demonstrator.

Designed specifically to solve farm industry problems:

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New! All-Weather Performance—C2-90 advanced air-cooled design performs in extremes of heat and cold.

In addition, this short stroke, oversquare engine has the advantage of modern high-speed operating ranges.

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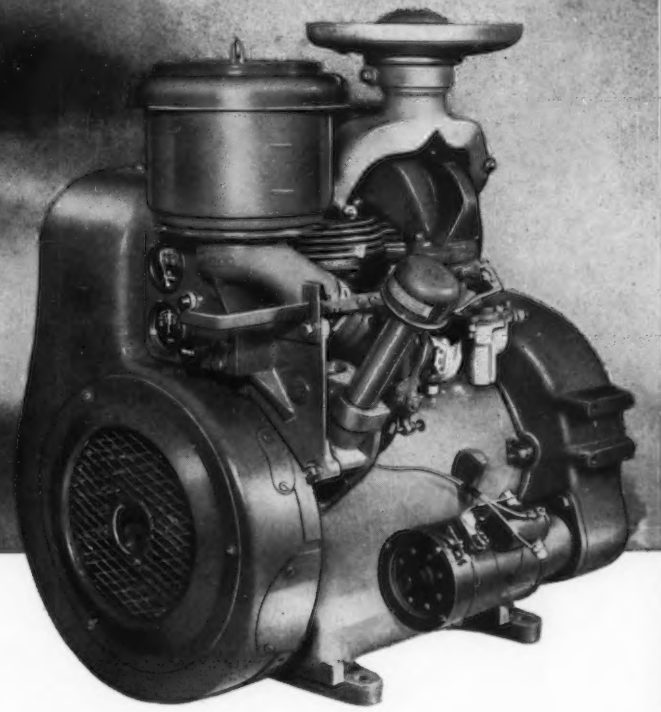

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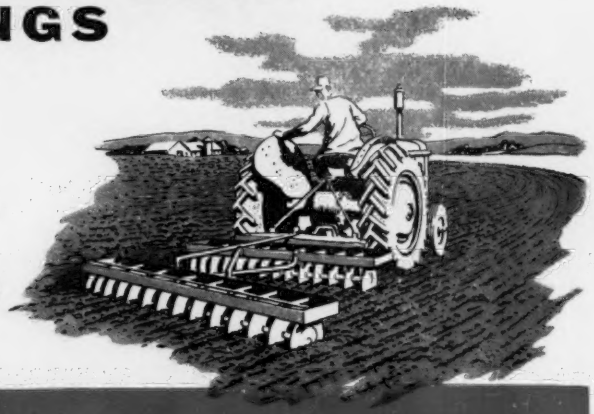
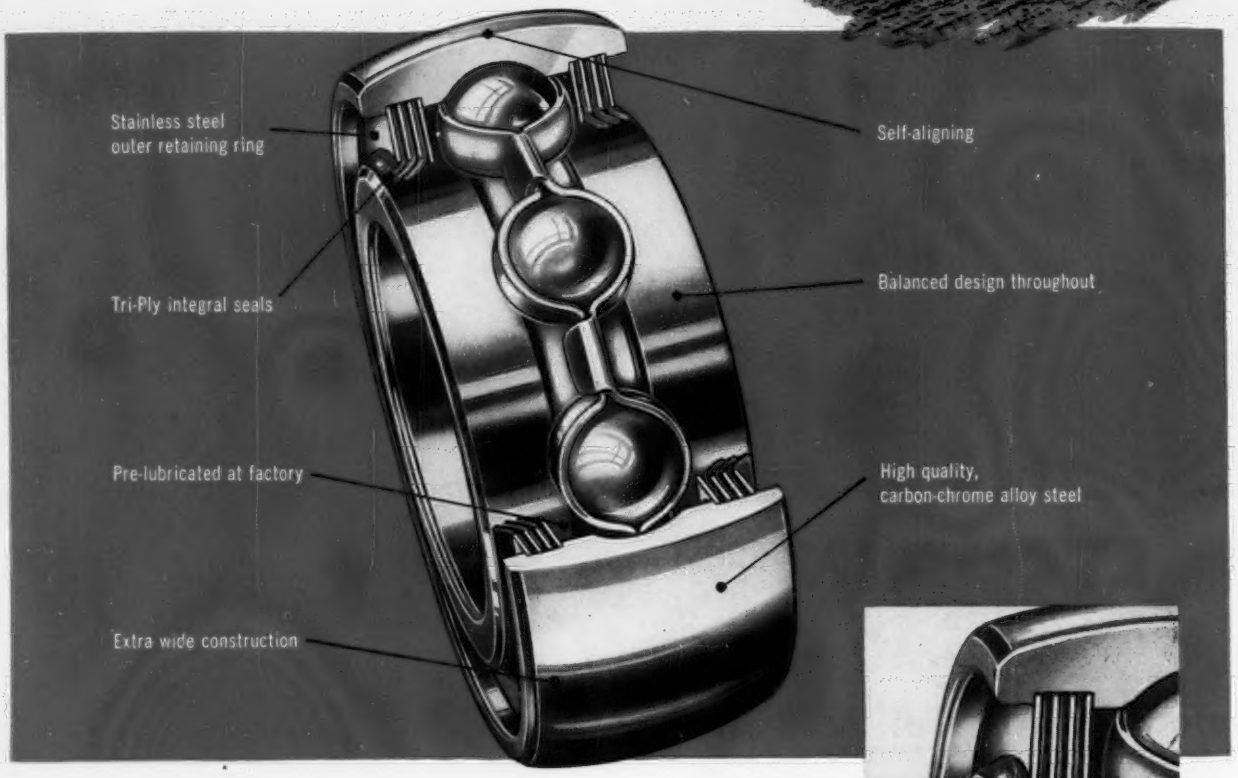
NEW! FAFNIR TRI-PLY-SEAL BALL BEARINGS

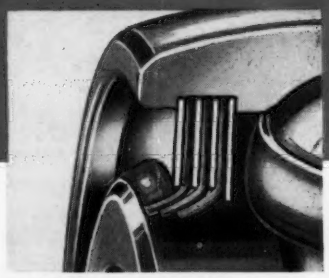
for application on

DISC IMPLEMENTS

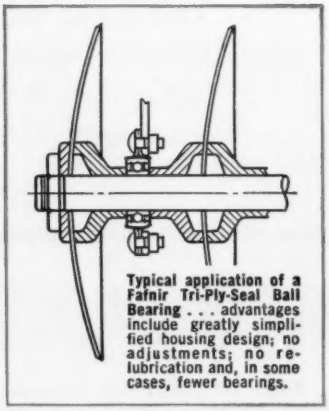




The outstanding feature of this new Fafnir development is *its tri-ply, integral sealing.* Effective retention of lubricant and protection against contaminants have been proved by destructive tests at the factory and in the field. Test bearings have been in continuous operation for over 2500 hours in a cement dust box without any signs of failure. Variations in the standard type of Fafnir Tri-Ply-Seal Ball Bearings may be obtained to meet special housing requirements. Additional details including dimensions are available in a new bulletin. Write The Fafnir Bearing Company, New Britain, Connecticut.



Fafnir Tri-Ply Integral Seals . . . unequalled protection for ball bearings in Disc Implements



Typical application of a Fafnir Tri-Ply-Seal Ball Bearing . . . advantages include greatly simplified housing design; no adjustments; no relubrication and, in some cases, fewer bearings.

FAFNIR
BALL BEARINGS

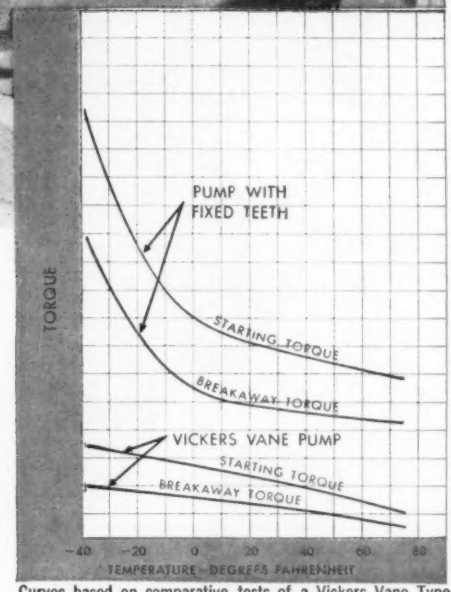
MOST COMPLETE LINE IN AMERICA

When Tractor Hydraulic System has a VICKERS® Balanced Vane Type Pump

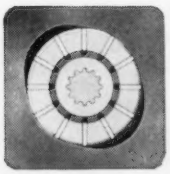
Under the very best conditions, cold weather puts a strain on starting equipment. Every part of the engine is stiffer, and the cold seriously decreases the power of the starting battery. If the hydraulic system has a pump with fixed teeth or lobes, this starting load may be seriously increased above normal.

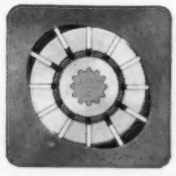
Vickers Balanced Vane Type Pumps *start at practically no load.* At rest and at normal starting speeds, the sliding vanes are retracted . . . only after the engine fires do the vanes extend and pumping begins. As a result, cold weather starting is much easier when a Vickers Vane Type Pump is used.

Get in touch with the nearest Vickers office for full information.



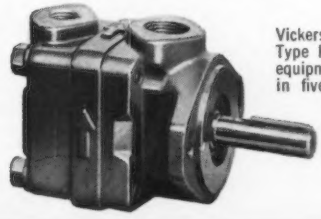
Curves based on comparative tests of a Vickers Vane Type Pump and an equal capacity pump with fixed teeth. Oil used in both was SAE 10W premium grade.





(Left) Schematic diagram of Vickers Balanced Vane Type Pump showing how sliding vanes are retracted at normal engine cranking speeds. No oil is pumped and there is practically no starting load.

(Right) Similar diagram of Vickers pump showing how pump vanes are extended when engine is running. Pumping then begins and continues at all engine speeds.



Vickers Balanced Vane Type Pumps for mobile equipment are available in five basic sizes, 15 normal delivery ratings and a variety of mountings. Ask for new Catalog M-5101.

6628

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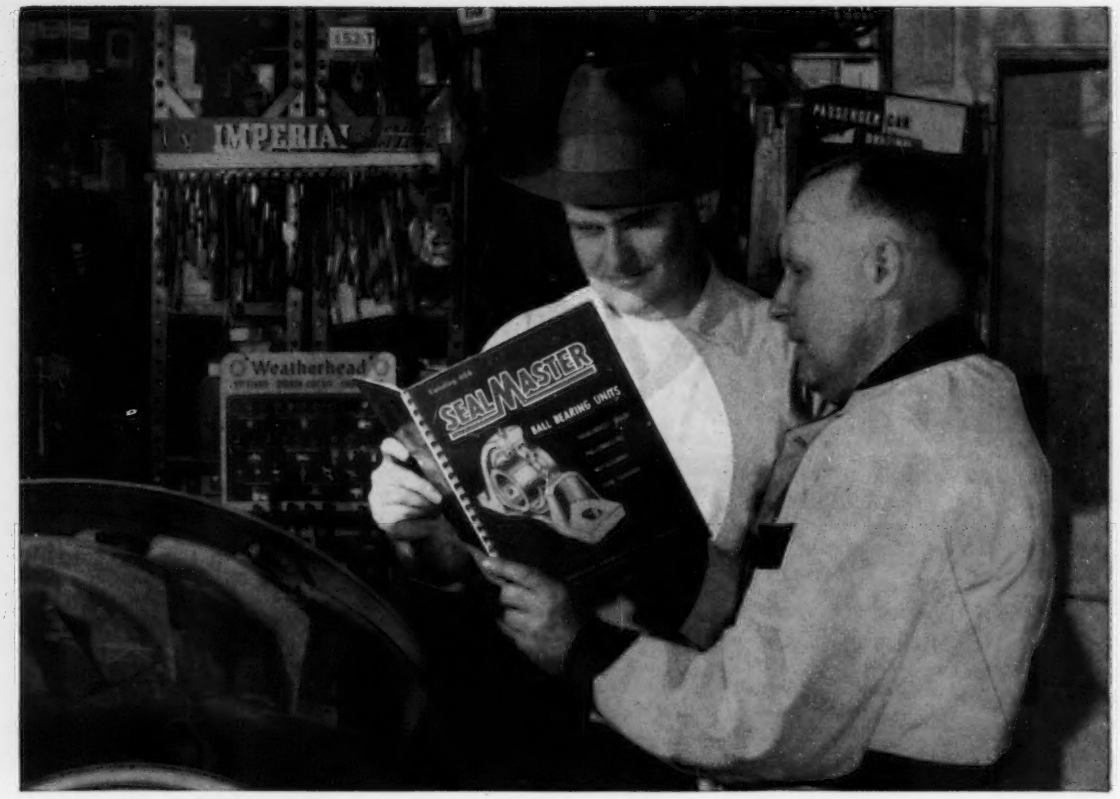

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One of the most significant trends in the farm field during the past year has been the increasing demand for quality in farm machinery. Initial purchasing price is of importance to the farmer but operational expense over the long haul is the **big** thing. The machinery market is competitive and the farmer has become a careful buyer. He's interested in a piece of machinery that will give him top performance and eliminate costly hours of maintenance. No component you build into your product will mean more to its efficient performance than the bearing units carrying the load. Insist on SEALMASTER and be sure!

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A Division of STEPHENS-ADAMSON MFG. CO.
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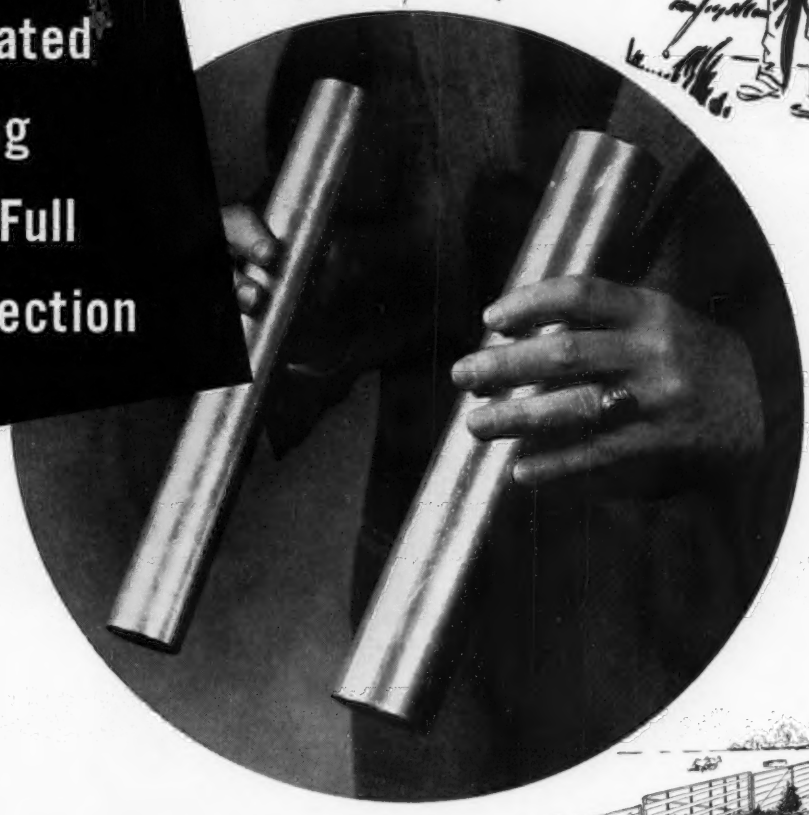

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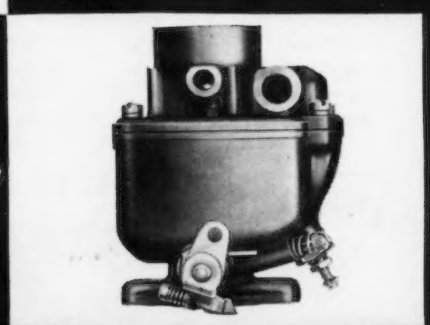

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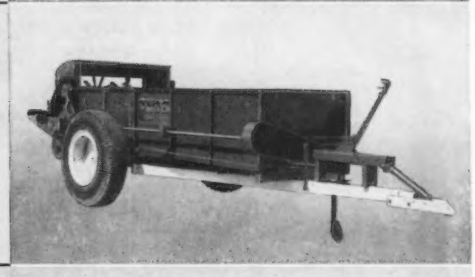

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Compared with older drive mechanisms, the modern p.t.o. powered manure spreader provides easier operator control, for more even spread of volume desired at various speeds. And in designing these up-to-date spreaders, each implement builder logically specified Blood Brothers Universal Joints and Drive Lines.

As the "Standards of the Industry," they assure the trouble-free, long-lasting service that farmers expect.

FOR FARM IMPLEMENTS, MORE BLOOD BROTHERS UNIVERSAL JOINTS ARE USED THAN ALL OTHER MAKES COMBINED.

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Oakland	Pimental & Son . . . . . 401 Eighth Ave.
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Salinas	Haag Diesel & Electric . . . . . 137 Abbott St.
San Bernardino	Diesel Injection Service . . . . . 932 Mill Street
San Diego	Electric Diesel & Equipment Co. . . . . 1268 Kettner Boulevard
San Francisco, 24	McKinley Corporation of California . . . . . 2196 Palou Ave.
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New Orleans, 13	John M. Walton, Inc. . . . . 1050 Carondelet St.

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Knoxville, 15	Diesel-Magneto Service Co.	1423 Island Home Ave.
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Houston	Diesel Pump & Injector Service	6632½ Navigation Blvd.
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Montreal	Northam Equipment, Ltd.	4135 Rouen St.
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Toronto	A. Cross & Co., Ltd.	6 Spadina Ave.
Toronto	Auto Electric Service Co., Ltd.	1009 Bay St.
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Vancouver	Jeffree & Jeffree, Ltd.	775 Homer St.
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That's why it's simply good business to make sure your customers get original equipment quality when replacement parts are needed.

When it comes to discs, always order direct from your implement manufacturer. He knows what discs are best for his tillage tools—the type, size and quality that will give your customers the most satisfactory service.

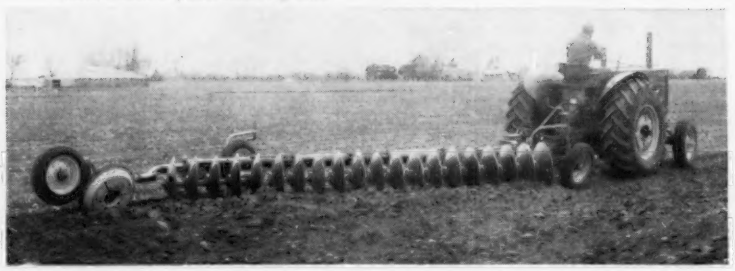
Ingersoll supplies *all* leading implement companies with original equipment and replacement discs. And the replacement discs duplicate the original discs in every detail. Made to the same specifications. Made from the same super-tough Ingersoll TEM-CROSS® steel—the steel that's *cross-rolled* for greatest resistance to impact and fatigue, and specially heat-treated for extra toughness and resistance to abrasion.

To be sure of this original equipment quality in the replacement discs you sell, order direct from your implement maker.

Ingersoll
Heat Treated
Discs

Ingersoll Discs turning deep furrows on John Deere No. 803 Disc Plow.

Flexible John Deere Surflex Tiller and Ingersoll Discs assure uniform penetration of ground.



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AGRICULTURAL ENGINEERING

VOL. 36 NOVEMBER, 1955 No. 11

Oscillation of Tillage Implements

Jack T. Gunn and V. N. Tramontini
Assoc. Member ASAE

Engineers reveal that oscillation of soil-working parts on tillage implements reduces draft and permits use of lighter tractors. Power not utilized by draft, because of traction limitations, is available through the tractor power take-off to oscillate soil-working parts of tillage implements. This in turn reduces draft

THE draft requirements of a tillage implement can be reduced substantially by oscillation of the soil-working parts. This has been demonstrated in a series of experiments at the University of California's college of agriculture at Davis. The agricultural engineering department of the college has been studying the effects of oscillation on the draft and power requirements of an experimental tillage implement similar to widely used subsoiling chisels.

Early attempts by the authors to establish the effects of oscillation on the performance of tillage implements by using model techniques were not successful. The problem was complicated by many variables of machine and soil, emphasizing a need for keeping the experimental work as simple as possible.

To simplify field testing, the work was confined to a single mode of oscillation of a geometrically simple tillage blade (Fig. 1) resembling a subsoiling chisel. The experimental implement was tested in dry, hard soils somewhat like those encountered in subsoiling operations.

Theory

From fundamental theory, expressions were derived for the energy requirements of oscillating tillage implements as a function of conveniently measured system parameters. The theory involved is a simple, straightforward application of mechanics. The derivation is so made that it does not limit the results to a particular type of tillage implement or a particular soil type or condition. It is convenient, however, that the draft-vs-speed characteristic of the soil-and-implement combination be approximated by a straight line.

Many investigators of tillage implements, e.g., McKibben and Reed (1),* have expressed their data on the draft of various kinds of plows as a power function of speed. The exponent chosen generally lies between 1 and 2; McKibben and Reed propose 1.5 for all kinds of plows.

However, the exponent depends on many variables and therefore no rule can be given that will cover all cases exactly. The elements making up the draft of implements range from forces independent of speed (friction, for example), to those (such as acceleration forces) that increase with the square of the speed. The limited accuracy of methods of measuring tillage forces does not warrant great precision in curve fitting unless prohibitive quantities of data are taken. In any such measurement it must be assumed that the soil has the same characteristics at all times and places in the test plot. Of course, this will be only approximately true.

In view of the foregoing, the authors contend that the draft-speed characteristics of many tillage implements can be approximated by a straight line (power function with exponent 1) with sufficient accuracy for a great many engineering purposes. This will be true particularly for implements that do not transport, and hence do not accelerate, large quantities of soil; it will apply best when the range of speeds involved is not large. This assumption is substan-

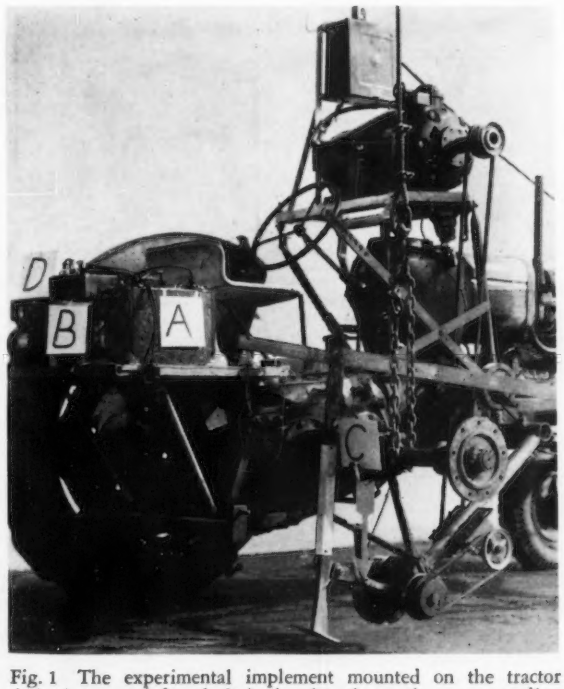

Fig. 1 The experimental implement mounted on the tractor (wheel removed for clarity) showing the strain-gage recording equipment (A, B, D), the crank-mounted strain gages (C), and the overhead electric motor drive for the chisel

This paper, prepared expressly for AGRICULTURAL ENGINEERING, is a summary of two theses presented by the authors to the graduate school of the University of California in partial fulfillment of the requirements for Master of Science degrees.

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Acknowledgments: The authors are indebted to L. M. K. Boelter, dean, college of engineering, University of California at Los Angeles, and to John B. Powers, chairman, thesis committee, college of agriculture, University of California, for guidance, inspiration, and helpful suggestions.

*Numbers in parentheses refer to the appended references.

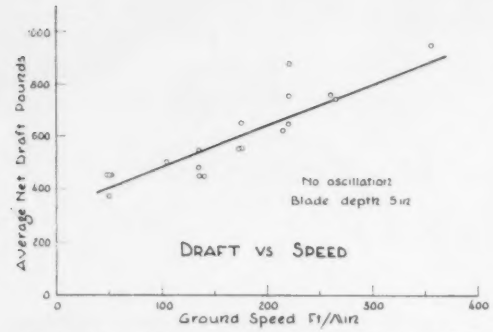

Fig. 2 Straight-line draft-speed characteristic of the experimental chisel

tiated for one type of implement in Fig. 2. The draft-vs-speed data shown were obtained with a non-oscillating chisel operating in a Yolo clay loam of 4.6 percent moisture content. These are represented reasonably well by the straight line shown. Similar straight-line results were obtained with this implement in other soils and at other depths. Thus, with reason, it may be assumed that this implement has a straight-line draft-speed characteristic with

$$D=mV+b$$

where D=average net draft, pounds

V=forward velocity of plow, feet per second

b=intercept, pounds

$m=dD/dV$, pound-seconds per foot.

If a pitman-driven mechanism is used to oscillate the plow fore and aft with approximately simple harmonic motion, the work integral Fdx can be evaluated easily between suitable limits so as to yield expressions for the power consumption.

To express the results of the derivation in a convenient and significant form it is useful to introduce several dimensionless parameters:

$$K=V_t/\omega r$$

$$L=m\omega r/b$$

$\bar{P}_o$=average oscillating power/$b\omega r$

$\bar{P}$=average total power/$b\omega r$

where ω=angular velocity of pitman, radians per second

r=eccentricity of crank, feet

V_t=forward velocity of tractor, feet per second

θ_1 and θ_2=crank angles between which the plow moves backward, radians.

When the maximum velocity of the implement (relative to the tractor) exceeds the tractor's forward velocity, the plow will move backward with respect to the soil during some part of the cycle. The displacement curves are shown in Fig. 3. During this part of the cycle it is assumed that the implement does no work on the soil because it is traversing a previously tilled path. This assumption is not completely accurate, but the complications involved in corrective mathematics probably would not be warranted by sufficiently increased precision. Since some energy is expended during this part of the cycle, it is expected that the theory will yield power requirements that are somewhat too low.

When these dimensionless parameters are introduced

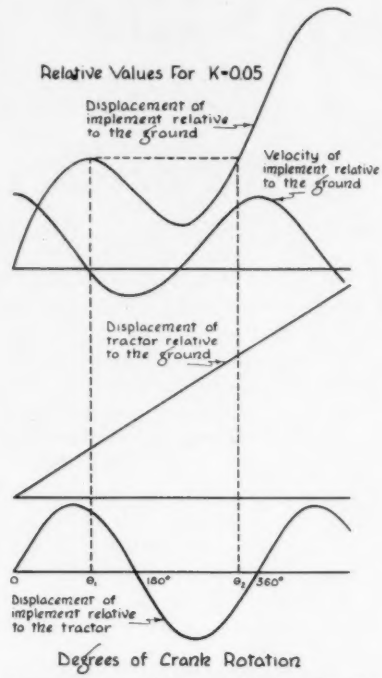

Fig. 3 Displacement curves for the oscillating subsoiler which show the regression of the implement relative to the ground during the part of the cycle θ_1 to θ_2

into the power expression, the following functions (curves plotted in Fig. 4) result:

For K greater than one

$$\bar{P}=(1+KL)+(L/2)$$

For K less than one

$$\bar{P}=[K\ (1+KL)+(L/2)]\ [2\pi-\theta_2+\sin^{-1}K]+\sqrt{1-K^2}\ [(3KL/2)+1]+(L/4)\ \sin\ 2\ \theta_2-(2KL+1)\ \cos\ \theta_2$$

In most applications, it is expected that the value of the dimensionless characteristic L will be small compared to 1.

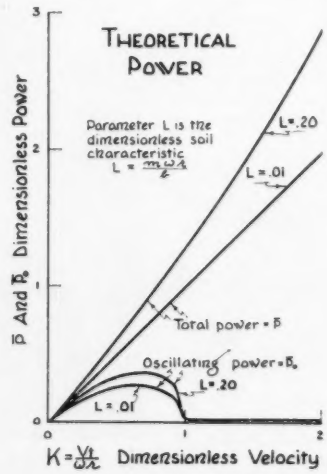

Fig. 4 Theoretical power curves for any oscillating tillage implement which has a straight-line draft-vs-speed relationship under non-oscillating conditions

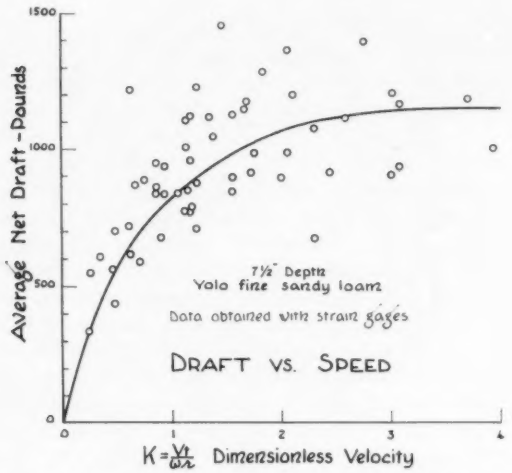

Fig. 5 Experimental curve showing the large reduction in draft obtained with increased rates of implement oscillation (i.e., smaller values of K)

This parameter (L) is dependent upon the characteristics of the particular soil and implement combination and must be obtained experimentally for each application.

It should be pointed out that the assumption of a straight-line draft-speed characteristic is not essential to the implications of the results obtained in the derivation. For any power function with exponent greater than 1 the same general conclusions would apply, but the resulting mathematical complexity of the expressions would restrict their usefulness.

The greatest reduction of draft is obtained by operating at values of K less than 1, i.e., at implement oscillating velocities that exceed the forward speed of the tractor. Fig. 5 points this out. With these conditions (K less than 1 and L small compared to 1) important simplifications can be made in the power expressions, as follows:

$$\overline{P}=K \qquad \text{and} \qquad \overline{P}_o/\overline{P}=(\theta_2-\theta_1)/2$$

These simplifications increase greatly the facility with which preliminary estimates can be made. The errors involved are negligible for most engineering purposes.

It is to be noted that, as K approaches zero, an increasing proportion of the power transmitted to the soil comes from the oscillating system. This corresponds to the operation of a jackhammer, where draft is much reduced by oscillation.

Experiment

To verify the theory, tests were devised to measure the draft and power requirements under both oscillating and non-oscillating conditions. Two kinds of instrumentation were used. Results obtained with a mechanical system in 1953 agreed well with those obtained with strain gages in 1954.

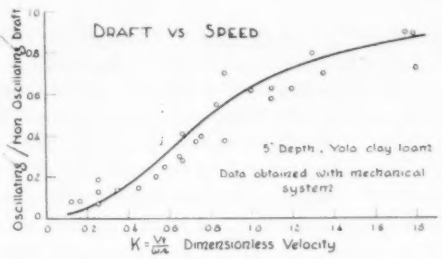
DRAFT VS SPEED
Oscillating / Non Oscillating Draft
5" Depth, Yolo clay loam
Data obtained with mechanical system
K = Vt/ωL Dimensionless Velocity

Fig. 6 Experimental curve showing the large reduction in draft obtained with increased rates of implement oscillation (i.e., smaller values of K)

The mechanical system used for measuring the average horizontal thrust on the blade is illustrated in Fig. 7. A vertical chisel standard, pivoted at its upper end (A), is connected to a pitman drive near the blade end (at the center of percussion) so that the blade and standard can be oscillated fore and aft at a controlled stroke and frequency. The additional linkage comprises the system for determining the reaction at point A, (the center of rotation of blade and standard) and, therefore, the force applied against the blade.

The beam CDF is constrained from rotation about D by spring scale G. The scale's spring, the dashpot J, and the massive beam comprise a mechanical low-pass filter such that the deflection of the spring scale is a measure of the average horizontal force applied against the blade.

To control ground speed independently of frequency of oscillation the experimental tractor (which drove the pitman from its PTO) was towed behind another tractor. The two tractors were connected by a drawbar dynamometer of spring-scale type to measure draft, thus providing a check of the mechanical system.

The strain-gage equipment was used to determine the average horizontal force against the chisel in two ways:

The first was by means of a drawbar dynamometer between the two tractors that consisted of a simple tensile member of tempered high-alloy steel to which were affixed

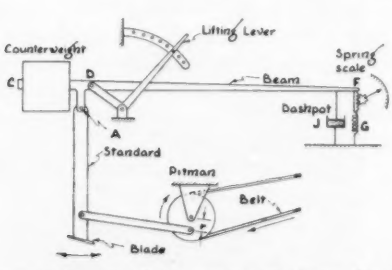

Fig. 7 Schematic diagram of the mechanical system for determining the average force on the blade by measuring the force at G. The dashpot J damps out vibrations

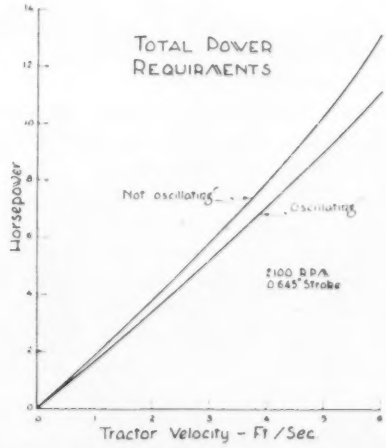

Fig. 8 The total power requirements are not much reduced by oscillation despite the large draft reduction so obtained

two active type C-3 strain gages. These gages were incorporated into a conventional bridge circuit excited by the 2000-cycle local oscillator of a Sanborn strain-gage amplifier. The output of the bridge was amplified suitably and rectified to drive a Sanborn recording galvanometer. Fig. 1 shows the galvanometer *(A)* and amplifier *(B)*, and the dynamotor *(D)* that supplied the instrument's current requirements. Within the limits of the galvanometer-amplifier combination, essentially flat to 60 cycles per second, the equipment recorded instantane us draft on a tape, for later graphical integration to determine average draft.

The second method was by using a series of strain gages affixed to the chisel standard itself. These gages responded to the beam stress caused in the standard by the soil forces on the blade. The output of these gages was recorded by an amplifier-galvanometer channel identical with that described above. Thus a check was provided in much the same fashion as was done for the mechanical system.

All four methods gave substantially the same results. The strain-gage drawbar dynamometer was the most convenient to use in the field.

Electrical means for calibration of the strain gages were incorporated in the amplifiers, but these were supplemented and checked frequently in the field by applying a known force to the system.

Since instantaneous draft could be recorded on a tape, it was practicable to record draft for runs of several hundred feet, for subsequent averaging. This extended record undoubtedly reduced the effect of local variations of soil characteristics and contributed to accuracy of measurement.

To measure the power required to oscillate the chisel mechanism a calibrated variable-speed transmission and electric-motor combination was mounted on the experimental tractor and belted to the pitman. This mechanism is shown in Fig. 1. Electric power was provided by a 60-kva diesel-driven alternator mounted on a trailer and towed behind the lead tractor.

Applying the power calibration curves required that the angular velocity of the pitman crank be both known and constant. A large flywheel fitted to the crank assured uniform angular velocity over the cycle. The average rpm of the crank was indicated continuously by means of an electric tachometer.

Chisel depth was controlled by a rigidly connected linkage adjustable to desired depth. Many of the data were taken at the depth limit of 7½ in.

The chisel stroke could be changed by fitting another crank to the pitman. Most of the data were taken at strokes of 0.322 in and 0.645 in, which correspond to crank eccentricities of ⅛ in and ¼ in respectively.

The soils in which the data were taken were a Yolo silt loam of less than one percent moisture and a Yolo clay loam of 4.6 percent moisture—both dryweight basis. The latter soil had a density of 87 lb per cu ft. The test plots were essentially level, barley-stubble fields. One of the fields was scraped flat and the other simply had the stubble burned off.

Results

The field work indicated that average net draft could be reduced greatly by oscillation of the experimental chisel.

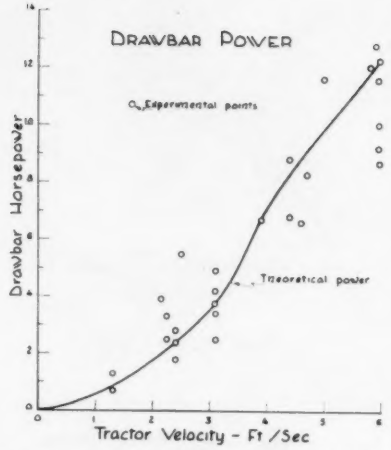

Fig. 9 A smooth curve through the experimental data lies near the theoretical curve and indicates the relatively close agreement between theory and experiment

The decrease was slight for oscillation velocities that were less than the tractor speed. Figs. 5 and 6 show the rapid reduction in draft that occurs as the forward speed of the tractor is reduced in comparison with oscillating velocity. (This corresponds to small values of K.) Fig. 5 represents the data taken with strain-gage equipment; Fig. 6 shows the results obtained with the mechanical system for a different soil and depth.

An important result of these experiments was that this reduction in draft was not accompanied by a large or significant reduction in the total power required to perform essentially the same tillage operation. Fig. 8 shows the power requirements under oscillating conditions contrasted with those for non-oscillating conditions.

Discussion

In Fig. 9 the drawbar power curve predicted by the theory is compared with the corresponding experimental points. Considering the probable experimental uncertainties inherent in tillage measurements, the data confirm the theory. A similarly close agreement exists between theory and data for other conditions, not shown here. The reduction in drawbar power in the region of K values of less than 1 is due to the increased transfer of power to the soil through the oscillatory system.

Note (Fig. 5) that for $K=0.25$ the draft is reduced by oscillation to about one-third. At the same time the total

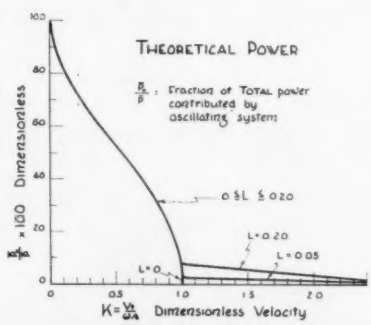

Fig. 10 This dimensionless plot clearly shows that the fraction of power contributed by the oscillating system increases rapidly as oscillation velocity increases, corresponding to smaller values of K

power requirements (Fig. 8) remain substantially constant. It had been hoped that there would be a substantial reduction in total power requirements. Such does not appear to be the case. There remain two possible practical advantages of an oscillating implement:

(a) Reduction in draft might enable a smaller tractor to employ the full power of its engine, even though it is incapable of developing sufficient draft to do so without oscillating the implement. This would come about by virtue of the alternative means of transferring energy to the soil—by the oscillating system driven from the PTO. Correlative with this approach is the possibility of using trailed implements with self-powered oscillating systems. These implements might enable a small tractor to perform a tillage operation usually requiring a much larger tractor. The draft reduction obtained by oscillation might be applied advantageously to garden tractors, which are usually made heavier than necessary in order to provide the necessary traction. Here weight reduction is desirable for ease of handling.

(b) The tillage performed with given power might be superior for oscillating equipment. The experiments gave a clear impression that oscillation produces much more fragmentation of the soil than does non-oscillation. Whether this is beneficial is an extremely complex question that must be answered by practical experience in each specific situation.

The first advantage above comes about because the maximum draft of a wheel tractor under usual conditions of operation is limited by wheel slip rather than by engine power. Consequently it is possible to utilize such excess engine power for oscillation of the implement. To determine if a particular situation offers a potential advantage the case must be analyzed from the standpoint of maximum draft obtainable under the conditions of operation, and draft-speed characteristics of tractor and implement.

Certain factors of interest to the designer have come to light in this study. The dimensionless velocity *(K)* is an important parameter of the system and one whose value should be small in comparison to 1. For a given tractor speed the value of K may be reduced by increasing either the crank throw or its angular velocity. The decrease is directly proportional to either alternative, but the inertia forces are proportional to the square of the angular velocity. As a consequence the designer probably will want to use a relatively longer stroke and a correspondingly lower frequency.

When maximum energy transfer to the soil is the major design criterion, the value of K should be 0.7. This can be verified by referring to Fig. 4. Alternatively, if minimum draft is the criterion, the value of K should be as low as other design requirements permit (Figs. 5 and 6).

It is of particular interest that none of the assumptions in the development of the theory are such as to limit the results to any particular implement or soil. Since the theory is well substantiated by the experimental work done with these particular soils and with this implement, it may well be that the theory has general and useful applicability. More work is needed to investigate this possibility. Other modes of vibration and greatly differing combinations of stroke and frequency that produce the same values of K should be investigated also.

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Endurance Course for New Farm Machines

TO accomplish the three-fold purpose of (1) aiding development of new types of farm equipment, (2) evaluating performance of current models, and (3) comparing equipment with competitive products, several farm equipment manufacturers are establishing what one company calls an outdoor evaluation center for tractors and farm machinery. Such a center, opened recently at Birmingham, Mich., by the Tractor and Implement Division, Ford Motor Co., provides for approximating for repetitive use, conditions likely to be found in the field, but which are not usually available in regular field tests. By using electronic equipment carried in a van which moves with the farm equipment while undergoing tests the performance of that equipment can be recorded for later evaluation.

The center consists of four "torture" courses inside ⅓-mile oval test track. These include an obstacle course, a "rumble" course simulating rutted fields, and two "pitch-and-twist" courses. Obstacles in the cement-paved courses are movable and can be set to induce special vibration or strains in the equipment undergoing tests. Slots are provided in the pavement of each course so that different height and shape obstacles can be attached for a particular test, but can be relocated for another series of tests.

Other features include an impact testing device, simulating a buried rock or other below-ground obstacle; a maypole to which driverless tractors can be moored and then set in motion; and a controlled-temperature holding room where stress-detecting coating can be "cured" before the implements enter the torture courses.

Engineering Developments in Watershed Programs

Robert S. Calkins
Member ASAE

Recent floods in the Northeast forcibly brought home lessons that some areas have been dragging their feet in the matter of providing adequate flood control dams to reduce flood damage. Many communities, however, are concerned and are doing something about it

MANY city and suburban water companies, during periods when water supplies are short, forbid sprinkling until after certain hours and only then when absolutely necessary. Yet, all too often, when the water situation approaches an acute stage, folks shrug their shoulders and pass it off. Cars are washed, pools filled, and lawns sprinkled during the emergency. It reminds one of the old saying that no one ever takes action until he is compelled to do so.

Some folks think through a problem, realize that an appropriate action should be taken, and then act. Others wait until the pressure of public opinion or the passage of a law or ordinance forces them into doing what must be done. Many well-meaning citizens do not understand why a private profit-making water company should request them to go easy on the use of water. Until folks do understand fully, many engineering developments in watershed programs will be postponed.

It is encouraging to know that here and there folks are aware of the problems and watershed programs are moving forward. In Salem, West Virginia, the local people actively are supporting the watershed program in the Salem Fork portion of Upper Ten Mile Creek. They have a compelling reason. They don't like to have their business areas and their bottom lands flooded. Damage has been heavy there.

Three key Salem Fork watershed residents represented their watershed association at a hearing before the West Virginia Public Service Commission. The hearing was held to find out whether the construction of a flood-water detention dam should be approved. These people wanted the dam approved and did not hesitate to make their wishes known. What is more, they understood why the dam was needed and what its construction would do for the community.

There was a bit of ingenuity used in the design of the first two dams for control of floodwater in that watershed. It was desirable to use a drop-inlet-pipe spillway and an earth-fill dam on this particular site. To permit ease of inspection and maintenance, it was desirable to use 24-in pipe. Requirements of the state and of the U. S. Soil Conservation Service were such that this principal spillway had to take care of a 100-year-frequency flood. The 50-cfs discharge from the 24-in pipe was slightly greater than the capacity of the natural channel below the dam. This problem was solved by providing two inlets to the principal spillway. A low-stage inlet was installed with 12-in-diam opening in the reinforced concrete riser. This opening will pass all of a 5-year-frequency flood with a maximum discharge of only 10 cfs. The reservoir will store water temporarily so that this low release rate is possible.

Now it is assured that the channel in the valley that overflowed annually or oftener will not overflow unless a 5-year-frequency flood is exceeded. The difference in peak flow and volume between a 100-year-frequency flood and a 5-year-frequency flood is carried by the 24-in pipe. An emergency spillway is provided to pass a 100-year-frequency flood just in case the principal spillway becomes plugged.

These emergency spillways are being designed today quite differently from the way they were designed in the northeast

Paper presented at a meeting of the North Atlantic Section of the American Society of Agricultural Engineers at Storrs, Conn., August, 1955.

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Fig. 1 *(Left)* Construction operations of Mason Dam, a flood-detention dam constructed in a watershed project near Salem, W. Va. • Fig. 2 *(Right)* Completed Mason Dam with the two-stage inlet illustrated

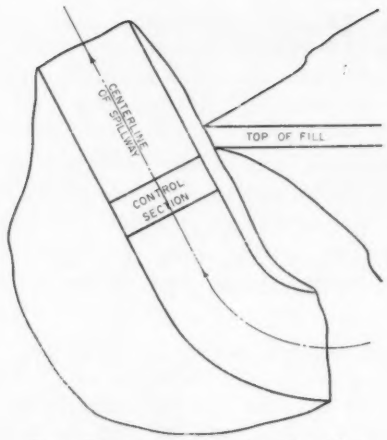

Fig. 3 Plan view of typical earth spillway

only a few years ago. At one time these emergency spillways, which are channels cut into undisturbed ground, were considered as broad-crested weirs. Their capacity was determined by an appropriate weir formula. Today, they are designed as open channels and more often than not a control section is constructed in them so that the hydraulic characteristics can be determined accurately. This control section is placed at the elevation where the first 100-year-frequency—or other desired frequency—flood crests. It is level across the width of the spillway and for a length of 20 ft or more along the center line of the spillway.

An approach channel with a rather flat but definite slope —usually 3 percent—is constructed to guide the flow to the control section. The approach channel often is curved to a considerable extent to facilitate getting water from the reservoir area to the control section. The exit channel is straight in alignment for as long a distance as possible. It is built so that the slope of the exit channel equals or exceeds critical slopes for all significant flows through the spillway. The length of the exit channel, *X*, Fig. 4, is such that a hydraulic jump will not back water over the control section, and destroy its effect.

Using the principles of channel flow and the energy equation, it is fairly simple to determine, for a given flow, the profile of the water surface between the reservoir and the end of the exit channel. Of course, these computations can

Fig. 5 Typical timber-rock crib used for stream gradient control in Dean Creek watershed near Spencer, N. Y.

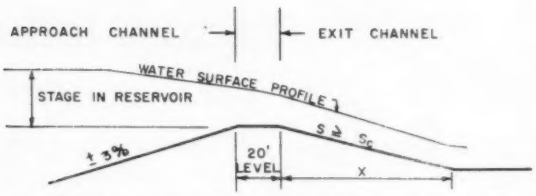

Fig. 4 Typical earth spillway profile along center line in Fig. 3

be carried further downstream when it is desirable to do so.

Earth spillways, as described above, are as satisfactory as any other type if properly designed, constructed, and maintained. Frequency of flow is a factor, too. Proper design of spillways for earth dams which include earth spillways as described above should include the use of a concrete or masonry spillway at a lower elevation to take constant or frequent flow. Good sod cover on earth spillways is most important.

Earth dams with drop-inlet spillways need not always have two-stage inlets. In the Ball Creek watershed in western New York, residents in the vicinity of Lake Chautauqua are concerned about the amount of silt in the lake. A dam is planned to take care of flood flow from a 4-square-mile watershed. The dam will reduce the peak flow of 1560 cfs in a 100-year-frequency flood to an outflow of about 100 cfs.

Below this proposed dam, an active stream bank is eroding at a furious rate. The reduction of peak flow plus revegetation of the bank will come mighty close to eliminating most erosion on the bank. Less sediment will be carried to Lake Chautauqua, to the relief of the watershed residents.

Sediment is a problem in other locations, too. For several years the residents of Princeton, N. J., have been concerned. Lake Carnegie receives too much sediment from the Stony Brook watershed. It is so bad that costly dredging and disposal operations are being contemplated. One answer to this problem is the construction of dams with high trap efficiency. These would trap much of the sediment and hold it above the lake. Best estimates for the Stony Brook watershed indicate that, for each square mile of watershed above a dam, there should be 40 acre-feet of sediment storage available in the permanent pool.

Several such dams and silt pools are contemplated in the Stony Brook watershed. There is opportunity for multiple-purpose dams in this New Jersey watershed. One of the possible silt-control dam sites is capable of more storage than is needed for trapping silt. Irrigation of 100 acres or more of high-value crops would be possible from the stored water. Funds provided by private interests for certain of these extra benefits may be pooled with federal funds in the watershed programs.

Sediment-control dams require a different kind of spillway. Reinforced-concrete drop spillways—the kind with a weir notch—will be used. Or, perhaps gravity section concrete or masonry spillways will do. These types are good for overfalls up to 8 ft or so. When the overfall is greater than that, reinforced concrete chutes may be used.

At the St. Anthony Falls Laboratory at the University of Minnesota, the U.S. Soil Conservation Service and the university officials have done a great deal of research on the hydraulics of these chute and drop spillways.

To reduce scour at the outlet of the drop spillways, special sills and wing walls have been developed. To slow

(Continued on page 735)

Factors Influencing Runoff

Orville E. Hays

A comprehensive report on runoff taken from the upper Mississippi Valley and Michigan experiment stations. Results include data on soil conditions caused by frost, snow, organic matter, slope, temperature, crops, fallow, vegetation, woods, crop residue and fertility

THE conservation experiment station at LaCrosse, Wis., represents some 12 million acres in the states of Wisconsin, Minnesota, Iowa, and Illinois. The area is characterized by steep slopes with cropland on many farms on slopes as steep as 20 percent. Soils are high in silt which deteriorate rapidly under poor management, but which respond well to good management. The agriculture is largely dairying which provides a favorable outlet for hay produced in long rotations.

The annual precipitation averages 32 in with about 70 percent being received during the period of April 15 to November 15. Rainfall of the thunderstorm type, with highly erosive intensities, can be expected at any time during this period. These storms are extremely important from a soil and water management standpoint as four storms a year cause about 95 percent of the soil loss and 84 percent of the runoff with corn in the rotation.

During the winter period the soil can be expected to be frozen most of the time from November 15 to April 15. However, thaw periods can occur at any time and may remove part or all of the snow cover and part or all of the frost in the soil. Rains, even of low intensities, occurring on partially frozen soil may remove all snow accumulation and thus result in nearly 100 percent runoff of rain plus the snow accruement. This combination may thaw the upper surface of the soil and remove from sloping land much of the thawed layer of soil which is not protected by vegetative cover.

The amount of frost in the soil is an important factor influencing winter runoff characteristics. The depth of frost penetration and removal is influenced by snow depth, air temperature, vegetative cover, and land-slope direction. The most important factor appears to be depth of snow cover. Frost penetration studies made in Wisconsin at LaCrosse, Owen, and Madison show that during periods of low temperatures and little or no snow cover, frost may penetrate on cropland to as much as 3 ft. Heavy sod, crop residue, or surface litter wili help reduce frost penetration. Snow cover 24 in deep at Owen was found to prevent frost penetration, but 18 in of snow allowed further frost penetration into the soil when the weekly average minimum air temperature was 21 deg below zero. A soil which has frozen deeply and is then covered by a sufficient depth of snow will soften enough within a few days, even with continued low temperatures, so that it is noticeably easier to drive a pipe through it. The soil will also start to thaw at the lower frost line.

Vegetative cover will delay frost penetration in the fall and will also insulate against frost removal during periods when air temperatures are high enough to thaw plowed land. This factor frequently results in higher amounts of winter runoff from hay and grass areas than from plowed areas. A good growth of timber, protected from fire and grazing, allows less frost penetration than a field or pasture area because there is a mulch on the surface, a more uniform depth of snow cover, and less thawing of snow in the winter. The maximum depth of frost measured in woods at the LaCrosse station is 6½ in as compared with 3 ft under plowed land and 14 in under grass. Under woods the snow normally melts slower than on fields and pastures. Insulation provided by snow and litter allows the soil to thaw from the bottom up. In non-wooded areas spring thawing normally occurs from both top and bottom of the frozen soil.

The influence of vegetative cover on soil freezing and thawing characteristics has an important effect on winter runoff. A good stand of hardwood timber, protected from fire and grazing and from outside runoff, even though on a steep slope, has yielded no winter or summer runoff after 4 years of protection. This area was placed under measurement and treatment in 1932. There has been no winter runoff for 18 years, or since the spring of 1936*.

Bluegrass sod, even though protected from fire and grazing, does not afford sufficient insulation to prevent deep penetration of frost into the soil. It therefore yields more runoff in the winter than in the summer.

Protected bluegrass yields somewhat less runoff, both in winter and the summer growing season, than does mowed or probably pastured grass. Hay land reacts similarly to grassland with more winter than summer runoff.

Generally a plowed soil allows less winter runoff than hay or grass land, if the plowed soil is in a good management program. Patches of dark soil, free of snow, will start to thaw and will hold considerable water whereas a vegetated soil does not thaw out so rapidly.

TABLE 1. EFFECT OF COVER ON RUNOFF
(6-year averages)

Treatment	Runoff, inches	
	Winter period	Growing season
30 percent, west-facing slope		
Bluegrass, protected	1.2	0.6
Bluegrass, mowed	1.6	1.4
Continuous corn	1.2	6.4
16 percent, south-facing slope		
Bluegrass, protected	1.8	0.03
Continuous corn	3.4	6.4
Corn after first-year hay	1.9	5.0
Spring grain after corn	2.4	3.9
First-year hay	2.5	1.4

Winter period, November 15 to April 15; growing season April 15 to November 15.

*Experiment conducted in cooperation with the Lake States Forest Experiment Station, U.S. Forest Service, St. Paul, Minn.

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Organic matter content of the soil, soil structure, and degree of erosion have important influences on runoff under both winter and summer conditions. The plots included in Tables 1 and 2 were late fall plowed for corn and spring grain. The soil is at a high point after hay and at a low point after corn insofar as soil structure and raw organic matter content are concerned. For an 11-year period, winter runoff from plowed hay averaged 1.2 in and from plowed corn stubble 1.6 in. The severely eroded plots, with 3 in of surface soil, had about 1 percent organic matter and the moderately eroded plots, with 6 in of surface soil, had about 1.6 percent organic matter in the top 6 in of soil. During the winter period, the severely eroded soil allowed 0.8 in more runoff than the moderately eroded soil. The effect of degree of erosion on runoff exerts its influence also on runoff during the growing season. This shows up especially in runoff from grain land with the severely eroded land allowing 0.5 in more runoff.

TABLE 2. EFFECT OF DEGREE OF EROSION ON RUNOFF
(11-year averages, 1943-1953)

Treatment	Runoff, inches			
	Moderately eroded		Severely eroded	
	Winter period	Growing season	Winter period	Growing season
Bluegrass, clipped	1.94	0.07		
Corn after 3 years hay	1.19	0.66	2.15	0.88
Spring grain after corn	1.63	1.63	3.33	2.14
First-year hay	2.57	0.49	3.17	0.40
Second-year hay	2.97	0.24	3.23	0.36
Third-year hay	2.44	0.11	3.08	0.32
CGHHH rotation average	2.16	0.63	2.99	0.82

In Table 2 it is shown that, as an average for all crops in the 5-year rotation under study, more than three times as much runoff occurred during the winter period as during the growing season.

The Agricultural Research Service, in cooperation with Michigan State University, is conducting watershed studies near East Lansing to determine the effect of land use on the hydrology of farm lands under varying snow cover and frozen soil. These experiments were established in 1940 in cooperation with the Soil Conservation Service.

There are two cultivated watersheds and one wooded watershed under study. The areas vary from 1.3 to 1.9 acres and are located on slopes of 6.0 to 6.5 percent. The soils are largely Hillsdale and Miami loamy fine sand and fine sandy loam. George A. Crabb, Jr., research project administrator, East Lansing, Mich., has made available to the author published (1)† and unpublished data for inclusion in this paper.

Detailed air and soil temperatures, as well as runoff data, are available from these studies. Mean air temperatures for the months of November, December, January, February, March, and April were compared as measured at LaCrosse, Wis., and East Lansing, Mich. Air temperatures in April are similar at the two locations. However, for the other five months, the average at LaCrosse was 22.0 F and at East Lansing 28.8 F. Temperatures also drop earlier in the fall at LaCrosse and stay lower longer. Lower December, January, and February temperatures result in deeper frost penetration and less runoff in these three months at LaCrosse than at East Lansing.

Winter runoff and air temperature data for 1947-1951 at the two locations are summarized in Table 3.

†Numbers in parentheses refer to the appended references.

TABLE 3. RUNOFF AND MEAN AIR TEMPERATURES
(1947-1951)

Month	LaCrosse, Wis.		East Lansing, Mich.	
	Runoff, inches	Mean air temperature	Runoff, inches	Mean air temperature
December	0.03	18.6	0.09	27.2
January	0.21	14.7	0.82	25.3
February	0.53	16.8	2.09	24.2
March	1.32	28.0	1.57	31.8

The insulation effect of snow cover was found to be great at East Lansing. With no snow cover, an air low temperature of 22 F resulted in a soil low temperature of 32 F in one day. An 8-in snow cover with an air temperature drop to 12 F lowered the soil temperature to 32 F in three days. Under wooded conditions it was observed that snow covers the ground for longer intervals than is the case under other vegetative cover, and exerts its influence more markedly in ameliorating the effects of extreme temperature drops. Any vegetal cover tends to reduce the receipt of solar heat (to soil) in proportion to the density of that cover. Vegetation exerts, then, not only a direct influence upon soil temperature but also an indirect influence upon almost every other factor affecting soil temperature changes and other hydrologic factors.

Runoff data by crops and watersheds by months are included in Table 4 for the period 1941-1954. During this period, corn was grown on watershed A or B 9 years, oats 6 years, first year hay 5 years, and second year hay 5 years.

TABLE 4. RUNOFF IN INCHES BY MONTHS AND CROP
EAST LANSING, MICH.

Month	Crop				Watershed		
					Cultivated		
	Corn	Oats	Hay-1	Hay-2	A	B	Wooded
January	0.29	0.73	0.30	0.49	0.40	0.43	T
February	0.83	0.62	1.74	2.21	1.44	0.94	T
March	1.50	2.59	1.32	0.82	1.50	1.51	0.17
April	0.21	0.53	0.02	0.03	0.25	0.14	0.07
May	T	0.27	0.08	T	0.09	0.06	0.10
June	0.37	0.34	T	0.01	0.20	0.19	0.09
July	0.02	T	0.02	0	0.01	0.01	T
August	0.10	0.06	0.03	0	0.05	0.06	T
September	0.12	0.18	0	0	0.08	0.08	0
October	0.15	T	0	0.04	0.05	0.06	0
November	0.01	0	0	0	T	T	0
December	0.06	0.03	0.08	0.12	0.12	0.09	0
Total	3.66	5.35	3.59	3.72	4.19	3.57	0.43
Nov.-April	2.90	4.50	3.46	3.67	3.71	3.11	0.24
May-Oct.	0.76	0.85	0.13	0.05	0.48	0.46	0.19

A direct comparison of cultivated crops is difficult to make as the rotation varied between and within the watersheds. However, disregarding this fact and using the average monthly runoff for each year a crop appeared on either cultivated watershed, the runoff pattern is similar to the LaCrosse data. Under all cover conditions there was more runoff in winter than summer. Hay land yielded almost the same amount of winter runoff as the average of corn and grain. Hay land affords good runoff control after April. For the 14-year period, the average annual runoff for cultivated watersheds A and B was similar even though the crop sequence and rotation varied, which would indicate that whether the land was in corn, grain, or hay had little influence on total runoff under the conditions of the Michigan experiment. Soil loss, however, was much less under hay than corn or grain.

Nearly all runoff from the wooded area occurred during the period of March to June whereas the bulk of the runoff from the cultivated watersheds, 2.7 of 3.4 in, occurred dur-

ing the months of February and March.

In Table 5 are included data for an 11-year period from selected runoff periods at LaCrosse, which resulted in the highest amounts of runoff from grain for any one month. Corn following hay allowed less runoff than any other crop throughout most of the year. Runoff from grain remained high until October. Runoff from first-year hay remained high until July whereas second and third-year hay, with more grass, reduced runoff effectively beginning in May. These are storms of highest intensities experienced during the 11-year period. They resulted in high soil losses and were of flood-causing characteristics. More years of hay in the rotation will reduce runoff in the summer but will increase winter runoff.

TABLE 5. SELECTED STORMS RESULTING IN HIGHEST RUNOFF FROM GRAIN FOR EACH MONTH AND RUNOFF FROM OTHER CROPS IN SAME RUNOFF PERIOD
1942-1952

Precipitation					Runoff, inches					
	Intensities, inches/hour									
Amount	5 min.	30 min.	60 min.	Month	Corn	Grain	Hay-1	Hay-2	Hay-3	Average, all crops
1.47*	0.61	0.28	0.26	January	0.62	2.53	2.46	2.16	3.78	2.31
Thaw				February	1.06	2.65	1.23	1.20	1.24	1.48
0.35*	V.L.**	V.L.	V.L.	March	1.87	1.90	0.77	0.88	1.10	1.30
0.94*	V.L.	V.L.	V.L.	April	1.10	0.96	0.14	0.34	0.72	0.65
1.67	6.72	2.64	1.42	May	0.06	1.16	0.58	0.31	0.09	0.44
2.41	3.96	2.44	1.62	June	0.62	1.45	0.73	0.06	0.02	0.58
3.29	2.76	1.70	1.25	July	0.62	1.12	0.02	0.02	0.12	0.40
1.01	4.56	1.22	0.62	August	0	0.24	0.02	0.03	0.02	0.06
2.69	3.24	2.08	1.07	September	0.08	0.46	0.14	0.02	0.03	0.15
2.13	2.52	1.58	0.90	October	0.02	0.01	0.01	0	0.02	0.01
1.33	4.80	1.18	0.64	November	0	0	0	0	0	0
0.54*	0.36	0.12	V.L.	December	0	0.22	0.31	0.16	0	0.14
	Winter period total, November - April				4.65	8.26	4.91	4.74	6.84	5.88
	Growing season total, May - October				1.40	4.53	1.50	0.44	0.30	1.64
				Monthly average	0.50	1.06	0.53	0.43	0.60	0.62

* Rain and thaw combination.
** V.L. indicates intensities of less than 0.12 in per hr.

During these intense storms grain land yielded about twice as much runoff as corn or hay. There was not much difference in runoff from hay and corn. In order to determine influence of season on runoff from the three crops, the data from intense storms were grouped into winter (November to April) and growing (May to October) seasons. There was 3.7 times as much runoff in the winter, as an average for all crops. The greatest amounts of runoff occurred from spring grain in both periods. Runoff from corn was slightly less than from first-year hay. The older the hay, the more runoff in winter, the less the runoff in the growing season. In the growing season second and third-year hay allowed about one-fourth as much runoff as corn land and about one-twelfth as much as grain land. Hay, then, does reduce runoff water yield effectively in the summer and therefore would influence floods.

One year of corn, even following three years of hay, reduces the raw organic matter content of the soil and the soil structure sufficiently under present tillage methods so that extremely high soil and water losses are common from spring grain the following year.

Flood peaks and total water flow are influenced by a large number of factors. An important factor is thought to be the vegetative cover on the soil at the time of the rain or thaw. It, of course, must be recognized that a particular soil condition has a maximum infiltration rate which will be reduced by change of surface condition during the runoff period and will be reduced to the rate of percolation through the slowest soil zone during prolonged periods of thawing or rainfall or any combination thereof.

The U.S. Weather Bureau office at LaCrosse has made available for the author's use flood records on the Mississippi River, measured at LaCrosse, the Chippewa at Chippewa Falls, Wis, and the Root River at Houston, Minn.

The Mississippi River plus tributaries at LaCrosse includes a drainage area of approximately 62,900 sq mi. Flood-occurrence and peak-stage records are available for the period 1875 to 1934, inclusive. During the entire period, 90 percent of the floods occurred during the season of April to October, inclusive. In an attempt to determine the influence of timber cover on flood occurrence, A. D. Sanial and N. A. Matson of the U.S. Weather Bureau divided the data into two periods — 1875 to 1904, period of heavy forest cover on northern and central Wisconsin soils, and 1905 to 1934, period of rapid forest removal and incline in farming. The relation of forests to runoff on the Mississippi River could not be established definitely.

Data available from the Chippewa River (9,000 sq mi), for the period 1889 to 1934, indicated that the most destructive floods occurred in late March and early April. These data were divided into two groups similar to those from the Mississippi—1889 to 1911, forested, and 1912 to 1934, predominantly farmed. In the forested period, spring floods occurred about 20 days later than in the farm period.

For the Root River, with a drainage area about 1,660 sq mi, data are available for the period 1937 to 1953. During this period of measurement, 53 percent of the floods occurred during the period of April to November, inclusive. On all three streams, over 50 percent of the floods occurred during the months of March, April, and May. During the farming period, that is, after 1904, March floods have been on the increase.

During the months of March, April, and May, for selected storms (Table 5), corn and grain averaged 3.5 in of runoff, first-year hay 1.49 in, second-year hay 1.53 in, and third-year hay 1.91 in. On the average, during this period of high flood occurrence, hay yielded about 45 percent as much runoff as corn and grain. Only 3 percent of the floods occurred during the winter months of December, January, and February. This is the only period during which hay land at LaCrosse, would be expected to yield more runoff than corn or grain land.

Table 6 shows soil and water losses for the entire year at LaCrosse. Data are averages of moderate and severe erosion, 1943-1953 inclusive.

TABLE 6. ANNUAL SOIL AND WATER LOSSES FROM A 5-YEAR ROTATION
(16 percent slope, 11-year average)

Crop	Runoff, inches	Soil loss, T/A
Corn	2.4	4.9
Oats	4.3	11.4
First-year hay	3.3	0.7
Second-year hay	3.4	0.3
Third-year hay	3.0	0.3
Average	3.3	3.5

Oat land lost about 1.8 times as much runoff and 2.3 times as much soil as corn following hay. Losses from

spring grain can be reduced in several ways. Subsurface tillage with a large field cultivator in place of plowing after corn reduced runoff during the growing season from 3.6 to 2.9 in and soil losses from 2.2 to 0.8 tons per acre. An application of barnyard manure following seeding reduced runoff from 3.3 to 2.8 in and soil losses from 2.9 to 2.1 tons per acre.

The most effective method of reducing losses from grain land is to have grain follow hay with the seedbed prepared with a large field cultivator. In this experiment, plowed oats land after corn lost 3.4 in of runoff and 28.6 tons of soil per acre. Oats following hay, with seedbed prepared with a field cultivator, lost 1.4 in of runoff and 5.8 tons of soil, a reduction of 2 in in runoff and 22.8 tons in soil loss.

Grain after pasture may be planted on either plowed or subsurface tilled land. Fall plowing allowed 1.2 in of runoff and 2.5 tons soil loss whereas subsurface tillage allowed 0.6 in runoff and 1.1 tons of soil loss per acre. Subsurface tillage of hay land in seedbed preparation for grain in pasture renovation reduced runoff by 0.6 in and soil loss by 1.4 tons per acre.

Subsurface tillage, rough seedbed preparation, long rotations, proper use of barnyard manure, and good fertility practices all help to produce good yields and reduce soil and water losses, but they, in themselves, will not give adequate erosion and runoff control on long slopes when intense rains occur. Strip cropping and terracing are musts in a good soil management program on sloping land. Strip cropping reduces soil losses about 50 percent from those of contour planting in the same rotation but has little influence on runoff.

TABLE 7. EFFECT OF CONTOURING, TERRACING, AND STRIP CROPPING ON RUNOFF AND SOIL LOSS
(5-year period)

Treatment	Runoff, inches			Total soil loss, T/A
	Winter period	Growing season	Total	
Contouring	1.3	2.5	3.8	14.4
Terracing	1.2	3.3	4.5	2.8
Strip cropping	1.7	2.3	4.0	3.8

Runoff data from three watersheds are shown in Table 7. Under soil and climatic conditions at LaCrosse, strip cropping allowed more winter runoff than contouring. Terracing reduced winter runoff but increased runoff in the summer. These are graded terraces with a maximum grade of 6 in per 100 ft. Terraces reduce runoff in the winter due to the accumulation of snow in the channels which restricts frost penetration and allows part of the runoff water to infiltrate into the soil. In the growing season terraces yield more runoff but greatly reduce peak rates and increase the total period of runoff. Soil losses are at a minimum for crop land protected by properly designed and maintained terrace systems when cropped to adequate rotations.

Summary

Protecting timber from fire and grazing produces a soil condition which will prevent runoff.

The highest amounts of runoff were measured from spring grain following corn.

During intense storms, runoff from corn land was less than from first-year hay.

The older the hay, the more winter runoff and the less growing season runoff.

Second and third-year hay land yield one-fourth as much runoff as corn land and one-twelfth as much runoff as spring-grain land during intense, growing-season rains.

Strip cropping and terracing are essential for controlling runoff and reducing soil losses on sloping silt loam soils in this area.

References

1 Crabb, George A. Jr. and Smith, James L. Soil-temperature comparisons under varying cover. Bulletin 71 (1953), Highway Research Board, Washington, D. C.

Engineering Developments in Watershed Programs

(Continued from page 731)

down the water that slides through the chute, effective energy dissipators have been developed. These are called SAF stilling basins. The combination of sill and obstacles in the floor of the basin slows the water down.

Floods and sediment are not the only major problems in watershed programs. Bed-load movement is another.

In mountainous or hilly country where stream gradients are steep, bed-load movement reduces stream capacity at critical points. Fast-moving water picks up large particles. An obstruction in a stream such as a narrow bridge or a sharp turn slows water down and the load drops out. Result: the next flood flows over the banks. A road washes out. Business places or residences are flooded. Valuable crop and pasture land is ruined. Or a stream bank begins to scour seriously.

Timber-rock cribs have been used in the southern tier counties of New York to stop bed-load movement. The Erie Railroad has controlled several of such fast-flowing, steep streams with these structures. Apparently the railroad company prefers to clean out the debris behind these cribs every few years rather than to clean larger mounds of it from their tracks and bridges. One thing seems sure about controlling bed-load movement. The amount that can be carried varies with an exponential power of the flow. Thus a slight reduction of the peak flow greatly reduces the bed load carried. Studies of bed-load movement are limited, but engineers are coming up with new and interesting concepts. The meager results available piece together to broaden the scope of available knowledge on this subject.

It will be interesting to watch developments in New England. One of the most serious problems is gullying. Any structure installed to stop this gullying will require a head of water to make it flow. As this head develops, water is stored temporarily. When the space available for such temporary storage is large, the outflow is small and the costs of the structure needed can be minimized.

Neighbors can work together on stabilizing gullies. They can pool their resources to construct one structure that may do the work of several that would be required if each landowner handled his own problem.

These are a few of the engineering developments in watershed programs in the Northeast. There are more but these are the major developments of the past two years. There really are no new or startling engineering principles involved.

The most interesting development in watershed programs is to see that local folks are aware of their problems. They are teaming together in watershed associations to solve the problems. They are developing, through their soil conservation districts, sound technical programs to get at the solutions. They are working with private interests and local, state, and the federal governments to get the job done.

The Hydraulic Sickle Drive

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Hydraulic power has been assigned to another task—it is becoming established as an economic and practical drive for highway-type mowers

HYDRAULIC sickle drives take advantage of two established principles. Sickles which have been used for mowing vegetation since the advent of farm machinery and hydraulic-power components which have been used extensively in various industries since the early 1900's. Applying rotary hydraulic power directly to a cutting mechanism results in smooth, cushioned sickle action, increased maneuverability, improved operator's convenience and reduced annual maintenance.

The first problem in replacing the mechanical-drive elements of a sickle with hydraulic components is the added initial cost. This added cost can be justified by increasing the performance of the unit, by reducing the annual maintenance costs, or by reducing lost operating time. Performance is increased in a hydraulic-sickle-drive mower by providing the operator with greater control over the mowing unit. For example, a jammed sickle can be cleared by reversing the direction of the sickle from the tractor seat. Annual maintenance cost and lost operating time are reduced by eliminating the mechanical-drive elements such as universal joints, gears and chains.

A mower used industrially is expected to operate in various extreme conditions. Anticipating the potential of hydraulic power to satisfy these extreme conditions met in industrial mowing, a hydraulic sickle drive was designed and developed which would accomplish the following requirements:

1 Maneuverable features to provide greater operator control of the unit, such as reversible sickle action to clear a clogged cutter bar from the tractor seat—sickle action independent of the forward travel, and continuous sickle action at various cutter-bar heights and angles.

2 The sickle driven with sufficient power to operate in the various extreme cutting conditions.

3 Safety devices incorporated in the drive to protect the sickle and structural members minimizing annual maintenance cost and lost operating time.

4 Noise and vibration reduced to increase wear life of the mechanical moving parts as well as to minimize operator fatigue.

The first step in designing a hydraulic drive to meet these requirements was to make a study of the various hydraulic-component combinations which could be used to drive a sickle. A few of the possible combinations are as follows:

1 A hydraulic ram actuated mechanically by the tractor engine and connected by hose to a remote ram mounted at the inner shoe and reciprocating the sickle by displacement of hydraulic fluid

2 A reciprocating motor driven hydraulically by a rotating pump connected to the tractor engine, with a suitable means of control

3 A rotary hydraulic motor driven by a rotary pump from the tractor engine with a suitable valve for controlling the direction of flow to the motor.

The mechanically actuated ram and remote ram in the first combination require a mechanical means to reverse the sickle action to clear a clogged sickle, with no added advantage over present mechanical mowers. Also, accurate volumes of oil need to be maintained in the circuit to receive equal lengths of stroke each cycle. In the second combination, the reciprocating motor requires a complex, intricate valving arrangement, not yet commercially available, to apply force in alternating directions at approximately 1000 cycles per minute.

After eliminating these first two possibilities, development began on the third combination because of its adaptability to present mowers and its use of commercially available hydraulic components. These components consist of a rotary motor connected directly to the cutting mechanism, rotary pump, four-way valve with hydraulic relief and necessary accessories such as lines, fluid and reservoir.

The next step was to determine the type and size of the various components by initially setting down the known quantities influencing the drive.

1 The tractor engine speed for mowing was 1425 rpm.

2 Maximum sickle speed was established at 1000 cycles per minute based on previous experience with mechanically driven mowers for industrial purposes.

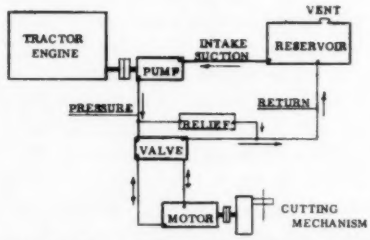
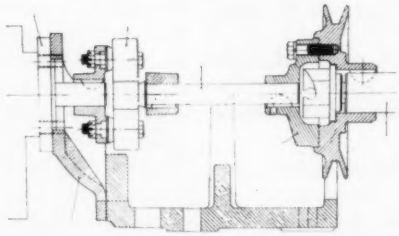


Fig. 1 The circuit diagram of the hydraulic system components



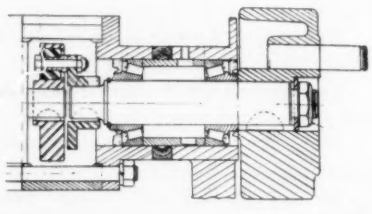


Fig. 2 *(Left)* Cross section of flexible coupling that drives hydraulic pump • Fig. 3 *(Right)* Cross section of flexible coupling that connects motor to cutting mechanism

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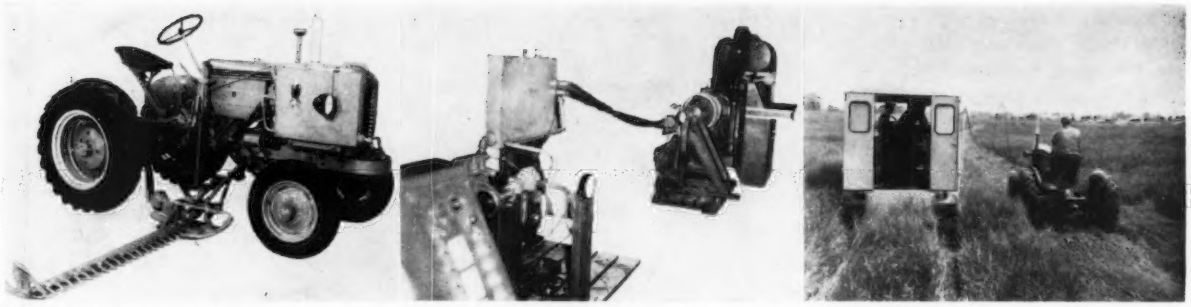


Fig. 4 *(Left)* The complete mowing unit • Fig. 5 *(Center)* Laboratory testing equipment • Fig. 6 *(Right)* Recording equipment for measuring field requirements

3 Six horsepower at 1000 rpm. was established to give satisfactory cutting capacity in the various extreme conditions. This horsepower estimate was arrived at by calculating the maximum torque which could be transmitted by the mechanical drive of an earlier industrial mower having desired capacity.

4 A 1000-psi pressure was established for preliminary calculations which is generally recommended by most hydraulic suppliers for this type of circuit application.

Using these known quantities, the motor-output requirements were established at 6 hp at 1000 rpm and 1000 psi. The next step was to select a type of rotary motor. Those commercially available are the gear, vane and rotary piston. In this particular application the spur-gear type offered the greatest advantage costwise and could satisfy the necessary horsepower output. A motor of this size was selected. Referring to the input-flow curve of this motor, it was found that the pump must supply 17 gpm at 1000 psi to deliver 6 hp at the motor shaft. A spur-gear-type pump was selected which delivered 17 gpm at 1425 rpm (tractor engine operating speed) and 1000 psi.

After determining the rotary pump and motor capacity, it was necessary to select a valve to control the direction of flow from the hydraulic pump. One of the requirements set down originally for the drive was to reverse the direction of sickle action. A four-way spool-type directional valve was used to accomplish this control. Also required of the valve was that the ports to the motor be open when in neutral position to allow the motor, attached crankhead and cutting mechanism to come to rest by mechanical friction rather than by a forced, abrupt stop, that would result if the ports were blocked suddenly. A hydraulic relief was built into the four-way valve providing a safety for the cutting mechanism. By locating this relief in the valve, surge pressures were prevented from carrying through the system when the valve was actuated.

The reservoir was designed for the greatest exposed area. The major purpose of the reservoir in this type of application is to accomplish cooling of the hydraulic fluid. Cooling is required because of losses in the circuit resulting from leakage, sudden enlargements or contractions, fluid friction, bends or elbows, and viscosity of the fluid.

The selection of the hydraulic oil depends greatly on its viscosity. A low-viscosity oil causes leakage through clearances resulting in energy loss. A high-viscosity oil reduces this leakage, but causes a resistance in closely fit parts, which also results in energy loss. Therefore, a compromise must be made by using a hydraulic fluid which will result in the greatest over-all efficiency. The final selection for this application was based on actual field test by using various readily available oils. It was found that SAE 20 oil gave the greatest efficiency in average industrial mowing conditions, but in extremely warm temperatures or in continuously tough cutting, SAE 30 was more desirable.

The hydraulic lines were designed to carry the maximum flow from the pump without turbulence or without excessive friction loss.

After determining the sizes and types of the various hydraulic components in the circuit, a pilot model was built and given considerable field test. Several minor changes or modifications were made during this testing period before arriving at the present version.

The circuit diagram (Fig. 1) shows the relationship of the various hydraulic components. The pump is driven directly from the tractor engine through a flexible coupling shown in Fig. 2. The four-way valve controls the oil flow, allowing it to flow into the reservoir, or into either side of the fluid motor. The relief, built into the four-way valve, allows oil at by-pass pressure to flow directly to the reservoir. This relief acts as a safety device for the cutting mechanism. When the sickle becomes jammed, pressure builds up

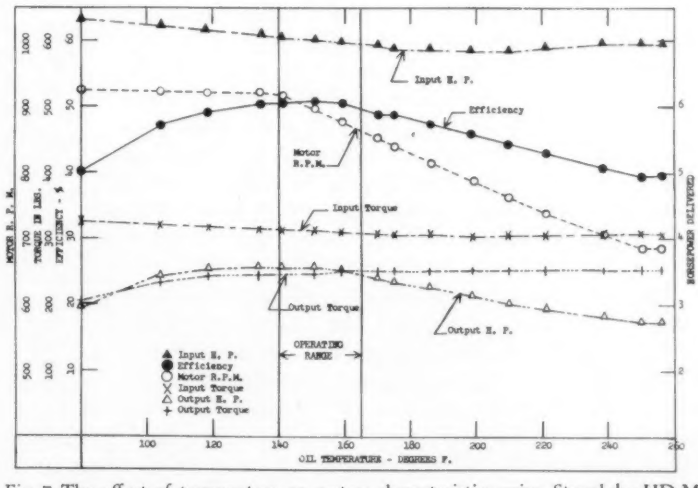


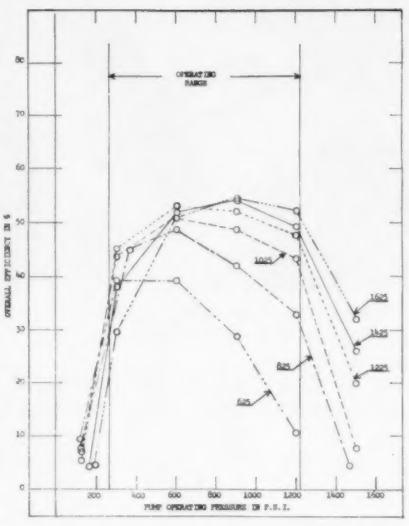
Fig. 7 The effect of temperature on system characteristics using Stanolube HD-M SAE 20 oil. Over-all characteristics are given at 600 psi, 1425 rpm pump speed and various temperatures

immediately actuating the ball-spring relief. If at this point the four-way valve is reversed, oil is directed at relief pressure to the opposite side of the motor, forcing the sickle away from any lodged material between the sections and the ledgers.

The motor is connected directly to the cutting mechanism by a rubber-cushioned flexible coupling (Fig. 3).

The complete mowing unit is shown in Fig. 4. The pump mounted at the front of the tractor is driven from the engine crankshaft. The reservoir is located between pump and motor to reduce the length of the hydraulic lines. The four-way valve is mounted on the reservoir. A control handle is within easy reach of the operator.

The hydraulic motor is mounted horizontally with the crankhead shaft allowing maximum maneuverability of the cutter bar. It can be raised vertically or positioned at any desired angle from 45 deg below to 90 deg above horizontal. A mechanical breakback is provided at the inner shoe to protect the cutter bar when an obstruction is encountered.



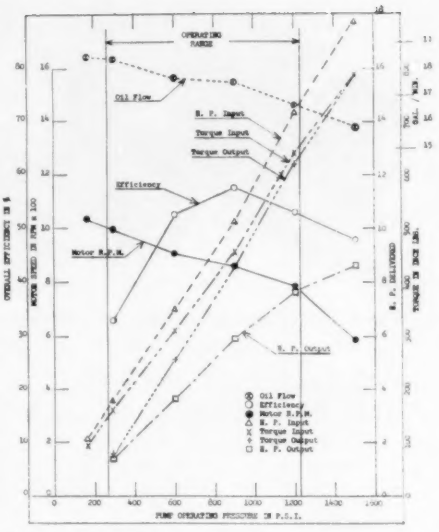


Fig. 8 *(Left)* Performance curve for mower hydraulic system with oil at 150 F, pump operating at different speeds, using 30 qt Stanolube HD-M SAE 20 oil • Fig. 9 *(Right)* Performance curve for mower hydraulic system with oil at 150 F, pump at 1425 rpm, using Stanolube HD-M SAE 20 oil, relief valve setting at 1750 psi

A second hydraulic system is provided for lifting the cutter bar. The pump for this circuit is driven from the engine camshaft. Two double-acting valves are mounted on the tractor to actuate two displacement-type rams lifting either the outer or inner shoe independently. Using this second hydraulic system for actuating the rams rather than the sickle-drive hydraulic system allows the cutter bar to be raised or lowered without changing the speed of the sickle.

The 5-gal-capacity reservoir uses a baffle to assure complete circulation of the hydraulic oil for maximum cooling. A vent, consisting of a filtering-type air breather is provided to protect the system from dirt or dust. A 20-mesh screen is used over the intake or suction line to prevent damaging particles from entering the hydraulic system.

After the development period, the finalized hydraulic drive was taken into the laboratory to determine the actual hydraulic circuit characteristics. The pump and motor each were attached to a dynamometer in order to read input and output torque and speed directly (Fig. 5). Thermocouples were installed at various points in the circuit to assure stabilized temperature readings. Pressure gages were located at the output of the pump and the input of the motor.

Fig. 7 illustrates the effects of oil temperature on circuit characteristics. From this test, it was concluded that the stabilized temperature should range from 140 to 165 F during field operation to give maximum efficiency. This data was used to design the reservoir. By calculating the heat transfer from the exposed area of the reservoir and lines, followed by actual field operation, the capacity of the reservoir was determined.

The efficiency of the complete hydraulic circuit at various pump speeds is shown in Fig. 8. A 5-ft sickle operated at 1000 rpm, from no-load to maximum relief pressure, is the operating range. Generally the efficiency increases as the pump speed increases at any given pressure. The shape of the curves shows low efficiencies at low pressures, since the system losses are a greater percentage of the horsepower input at these low pressures. The over-all circuit efficiency increases to approximately 54 percent at 900 psi and 1425 rpm pump speed. At higher pressures efficiency again decreases because of losses through clearances of hydraulic components and fluid friction in the lines.

The performance curves for the complete hydraulic drive are shown in Fig. 9. The oil flow from the pump at 1425 rpm and 1000 psi is 17.2 gpm. The power output of the motor is 6.5 hp at 1000 psi and 830 rpm. The maximum torque output of the motor at relief pressure is 635 in-lb.

The unit was taken into the field using recording equipment to provide some basis for determining field requirements. An oscillograph record revealed that the average input torque requirements were 170 in-lb and average input power was 4.1 hp. The peak input torque during the test was 204 in-lb. This test showed that in average mowing, very little force is required to actually cut the grass. However, a mower used industrially on roadsides and similar places must operate in various types of vegetation including reasonably heavy brush. To accomplish this, the drive must deliver enough power to the cutting mechanism to handle these extreme conditions, minimizing clogging or jamming of the sickle.

Correction

IN Peter Hebblethwaite's letter, captioned "Moduli of Uniformity and Fineness of Ground Feed," printed in AGRICULTURAL ENGINEERING for September, the legend for the graph on page 599 should read as follows: "Cumulative frequency curves for sieve analyses of a number of typical samples of barley meal fed to pigs."

Secondary Stresses in Glued Trusses

James S. Boyd and Henry Giese
Member ASAE Fellow ASAE

Stresses caused by the deformation of a truss with rigid joints are classed as secondary stresses. Because these stresses have been difficult to locate and calculate, engineers have often allowed for them in the factor of safety without knowing their actual values. The study reported here is concerned with locating and evaluating secondary stresses in rigid-joint trusses

IN THE design of trussed members it is usually assumed that all members are pin connected and that each member will resist only an axial force. The use of bolts and nails, however, imparts a degree of restraint. Glue has been found to be a desirable structural fastener and its use results in essentially rigid joints. The stresses caused by the deformation of a truss with rigid joints are classed as "secondary". The investigation reported in this paper was concerned primarily with these secondary stresses and their influence to the design of a timber truss. Other considerations were given to the analysis of secondary stresses related to problems involved in loading full-scale trusses and measuring strain in wood.

Von Abo (3)* indicates that the calculation of secondary stresses would lead to better distribution of metal in bridges and would result in a structure of more nearly uniform strength. He states that the factor of safety is used by engineers to allow for secondary stresses which are difficult to locate and calculate. He then classifies secondary stresses into the following types:

- Arising from rigid or partly rigid connections
- Arising from the beam action of members
- Developed in axially loaded members
- Due to faulty design and construction.

Design of the Truss

From a review of literature on wind pressures as summarized in Fig. 1, the following coefficients were selected for use in design:

Lower one-half of windward side of roof	+0.3
Upper one-half of windward side of roof	−0.2
Leeward side of roof	−0.5

These apply to the basic pressures created by the wind against a vertical surface.

With calculated wind pressure, a snow load of 25 psf (lb per sq ft) and a dead load of 5 psf, a theoretical analysis indicated that a snow load loading caused the highest stresses in the members. The wind loads reversed the direction of the stresses in the members, but reduced the magnitude.

From a cost analysis made of various plans for Fink trusses, either 4-ft or 6-ft spacing appeared to be economical. The 4-ft spacing was selected for this investigation because of convenience in using standard sheet materials. A 36-ft span was used.

Investigation

The dead load and snow load were considered as distributed uniformly. Concentrated loads at the third points of the top chords were selected for testing because they were convenient to apply and the resulting moments were comparable to those caused by uniform loading. The relative moments caused by these two loading conditions are as follows:

For a beam with a load P at the one-third points, the fixed end moment is equal to $2\ PL/9$.

However since $P = WL/3$, the moment would be $2\ WL/27$.

For a continuous beam loaded uniformly, the fixed-end moment is equal to $WL/12$.

Primary stresses were calculated by graphics assuming that the joints were pin connected (Fig. 2). With these stresses it was found that the top chords should be 2 x 8-in members and the web members should be 2 x 4 in as this was considered a minimum selection for practical farm construction.

A second source of stress results from the moment due

TABLE 1. SUMMARY OF CALCULATED AND MEASURED STRESSES FOR THE FINK TYPE TRUSS UNDER TEST

Member	Cross-section area in²	$z = \frac{I}{c}$ in³	Axial load lb	Moment from beam action in-lb	Moment from deflection in-lb	Calculated stress: Axial psi	Bend. +or- psi	Defl. +or- psi	Bend.+ Axial psi	Experimental stress: Axial* psi	Bend. +or- psi	Defl.** +or- psi	Bend.+ Axial psi	Defl.x 100 Bend.+ Axial percent
U_1L_0	12.2	.0656	-3700	+11,180	-2757	-303	733	181	-1036	-333	648	160	-981	16.3
U_1L_2	5.9	.281	-1000	- 494	+ 119	-169	139	33	- 308	-211	139	33	-350	9.4
U_1U_2	12.2	.0656	-3240	-10,686	+2638	-265	700	173	- 965	-334	628	101	-962	10.5
U_2U_3	12.2	.0656	-3240	+ 7,606	+1373	-266	500	90	- 766	-312	296	54	-608	8.9
U_2L_1	5.9	.281	+1100	- 24	+ 52	+186	7	15	+ 193	+212	10	22	+222	10.0
U_2L_2	5.9	.281	+1100	+ 24	- 52	+186	7	15	+ 193	+101	38	81	+139	58.2
U_2U_3	12.2	.0656	-3240	- 7,606	-1373	-266	500	90	- 766	-297	263	47	-560	8.4
U_3U_2	12.2	.0656	-3240	+10,686	+2638	-266	700	173	- 966	-288	645	160	-933	17.2
U_3L_2	5.9	.281	-1000	+ 494	- 119	-169	139	33	- 308	-216	69	16	-285	5.6
U_3L_3	12.2	.0656	-3700	-11,180	+2757	-303	733	181	-1036	-317	518	128	-835	15.3
L_0U_1	12.2	.0656	-3700	- 857	- 44	-303	56	3	- 359	-320	87	5	-407	1.2
L_0L_1	5.9	.281	+3320	+ 857	+ 44	+565	241	12	+ 805	+371	318	16	+689	2.3
L_1L_0	5.9	.281	+3320	+ 392	- 254	+565	110	71	+ 675	+394	222	104	+616	16.9
L_1U_1	5.9	.281	-1000	- 326	+ 36	-169	92	10	- 261	-232	213	23	-445	5.1
L_1U_2	5.9	.281	+1100	- 47	+ 145	+187	13	40	+ 200	+139	43	155	+182	85.0
L_1L_2	5.9	.281	+2200	- 19	+ 73	+373	5	20	+ 378	+427	8	34	+437	7.8
L_2L_1	5.9	.281	+2200	+ 19	- 73	+373	5	20	+ 378	+233	0	0	+233	0.0
L_2U_2	5.9	.281	+1100	+ 47	- 145	+186	13	41	+ 199	+142	30	56	+172	3.2
L_2U_3	5.9	.281	-1000	+ 326	- 36	-169	92	10	- 261	-210	44	5	-254	1.9
L_2L_3	5.9	.281	+3320	- 392	+ 254	+563	110	71	+ 673	+463	178	113	+641	17.6
L_3L_2	5.9	.281	+3320	- 857	- 44	+563	240	12	+ 802	+447	49	17	+496	3.4
L_3U_3	12.2	.0656	-3700	+ 857	+ 44	-303	56	3	- 359	-310	120	6	-420	1.4

* Average of stress on the four sides of each member

** Stress including bending plus deflection was measured as a combined stress and apportioned on the same ratio as calculated values.

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*Numbers in parentheses refer to the appended references.

to inter-panelpoint loading. The fixed-end moments on the top chords due to this type of loading are equal to:

$$\frac{2\,PL}{9}=\frac{2}{9}\left(\frac{18}{20.2}\times\frac{1100}{3}\right)(10\times 12)=8700 \text{ in-lb}$$

where P=load applied at one-third points of the upper chords of the truss in pounds
L=length between panel points in inches.

These fixed-end moments were distributed throughout the truss members by the principle of moment distribution. In this method the fixed-end moments at a panel point are distributed according to the I/L ratio of the members at a point, in which I is moment of inertia of truss member about the neutral axis and L is length in inches. After the distribution the resulting moments caused the stresses shown in Table 1.

A third source of stress is that caused by the deflection of the truss. The primary stress in each member will cause a change in length according to the relationship:

$$\lambda=SL/AE$$

where λ=change in length in inches
S=axial stress in pounds
L=length of the member in inches
A=area in square inches
E=1,940,000 psi (from test results).

These changes in length are summarized in Table 2.

TABLE 2. CHANGE IN LENGTH IN MEMBERS (INCHES) DUE TO AXIAL STRESS

L_0U_1†−.0188	U_3L_3−.0165	L_2L_4+.0391	U_2L_2+.0130
U_1U_2 −.0165	L_0L_1+.0391	U_1L_1−.0053	L_2U_3−.0053
U_2U_3 −.0165	L_1L_2+.0318	L_1U_2+.0130	

†Designation of members is shown in Fig. 2.

With these changes in length and the use of the Williot diagram, the deflections of all panel points were determined, assuming member L_1L_2 fixed in direction (Fig. 3).

The calculated deflections produce the moments which cause the stresses. These fixed-end moments were calculated by the following equation from Caughey (2):

$$M_{AB}=\frac{2EI}{L}\left(2\theta_B-\theta_A-\frac{3d}{L}\right)$$

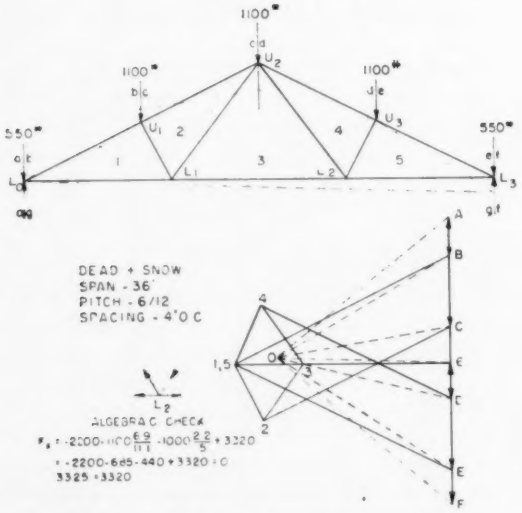
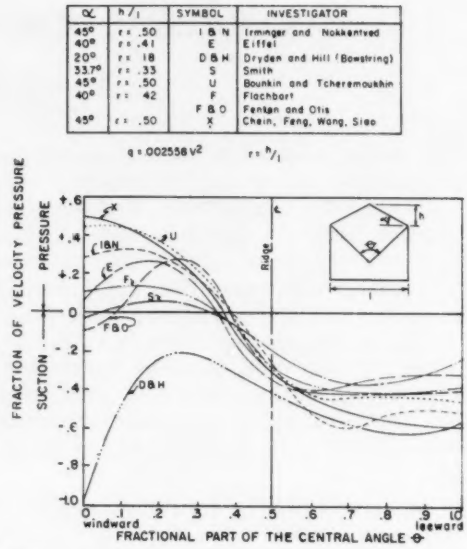


Fig. 2 Graphic solution for stresses in members due to loads as shown



α	h/l	SYMBOL	INVESTIGATOR
45°	r = .50	I & N	Irminger and Nokkentved
40°	r = .41	E	Eiffel
20°	r = .18	D & H	Dryden and Hill (Bowstring)
33.7°	r = .33	S	Smith
45°	r = .50	U	Bounkin and Tcheremoukhin
40°	r = .42	F	Flachbart
45°	r = .50	F & O	Fenton and Otis
		X	Chein, Feng, Wang, Siao

Fig. 1 Summary of velocity pressure coefficients obtained by various investigators

where E=modulus of elasticity, 1,940,000 psi
I=moment of inertia, inches
L=length, inches
d=deflection perpendicular to axis of member, inches.

In the test truss with glued joists, assuming no relative rotation between the members within the joist, both θ_B, and θ_A equal zero. Then the moment formula becomes:

$$M_{AB}=\frac{2\,EI}{L}\times(-3R)$$

The sign notation for the moments assumes those causing a clockwise resisting moment are positive and those causing counterclockwise resisting moment are negative. The moments were calculated and distributed among the members according to their I/L values. The stresses resulting from the distribution of moments are shown on Table 1.

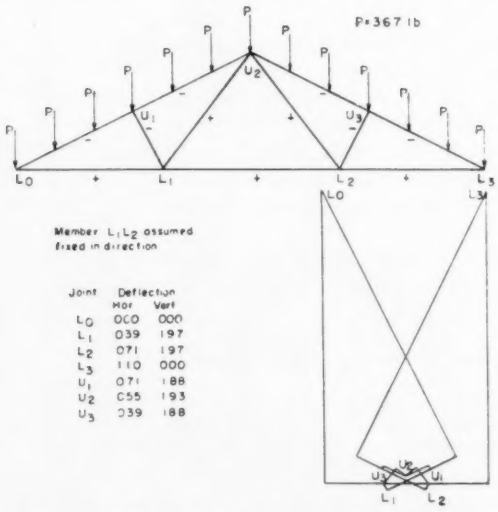


Fig. 3 Williot diagram to check joint deflections

Fig. 4 Truss ready for testing with all gages in place and roofing section on top chords

Fig. 5 *(Right)* Panel point U_1 showing the strain gages in position and wired to a selector switch

The test truss was constructed of No. 1 Douglas fir with a moisture content of less than 20 percent and the individual pieces were chosen with approximately the same density. Gusset plates were cut from ¾-in A-A exterior fir plywood and fastened with casein glue. Pressure for gluing was applied with 8d scaffold nails spaced 3 to 4 in apart. These nails were removed after the glue hardened.

The truss was supported during tests, in a horizontal position on a frame consisting of 2 in x 4-in joists variably spaced from 4 ft to 6 ft to prevent the gusset plates from resting on a joist (Fig. 4.) The top surfaces of the joists were coated with paraffin wherever a truss member and a joist made contact to reduce friction between the two.

Preliminary tests indicated that hydraulic cylinders could be calibrated easily and used to apply repeated loads quickly and accurately. A common hydraulic line to all of the eleven cylinders (bore, 2 in; stroke, 6¾ in; shaft, ⅝ in, and length 10⅝ in) resulted in equal loads applied simultaneously at the respective load points.

One end of each cylinder was connected at the loading point on the top chord by means of an iron strap as shown in Fig. 4. Oil was pumped to the cylinder through a ¼-in copper tube by a 3,000-psi hydraulic pump.

Seven Federal dial indicators and six Ames dial gages with a least count of one-thousandth of an inch, were used to measure the deflections of the panel points. A No. 12 wood screw 2 in long with a 1-in steel cube welded to the head was screwed into the truss at the panel points (Fig. 5.) The plungers from the dial gages rested on the surfaces of the cube to measure the motion in two directions.

In order to analyze the effects of secondary stresses, the unit stress at the ends of each member must be known. The axial stress is the average of the stresses on the four sides of rectangular members, and the bending stress is one-half the difference between the plus and minus stresses on the top and bottom of the member.

The basic unit for measuring strain was the SR-4 model A-1 strain gage having a gage length of 15/16 in and a gage factor of 2.06. Brittle lacquer was used to locate areas of maximum strain.

Single strain gages for measuring these stresses were located on the center line of each side of the member, as close to the edge of the gusset plate as possible (Fig. 5.)

The surface of the member was sanded, coated with a film of Duco cement and allowed to dry. A second coat of cement was applied to the strain gage before placing it on the member. Slight pressure was applied to the gage while the cement was drying. When thoroughly dried, the gage was coated with wax to protect it from damage.

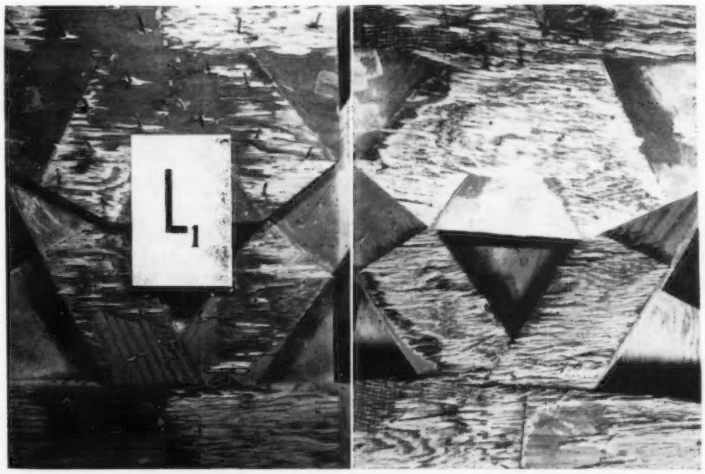


Fig. 6 Gusset plates on joint L_1 after failure occurred. View marked L_1 shows the side of joint with glue-starved area

Leads of No. 18 copper wire connected to the terminals of each gage with the selector switches made it possible to switch quickly from gage to gage without changing the balancing unit. The use of two balancing units eliminated errors in reading which might result during the test from changing leads between switch panels and balancing instruments.

The loads were applied in increments of 50-psi fluid pressure or 133 lb per cylinder. Readings of all gages were made while the loads were kept constant at the determined value. The truss was loaded well over the design load and the strains at the design load for each point read from charts plotted for that point. In this way local variations could be checked so they would not affect the strain to be used in the calculations. A series of three loadings and unloadings were made and the average of the strains calculated. The average strains at the design load were then multiplied by the modulus of elasticity (E) of 1,940,000 psi to obtain the unit stress at the design load. These unit stresses are shown with the calculated stresses in Table 1.

The use of glue for assembly of plywood gusset plates presents a practical method for joining the members of timber trusses. In one joint, however, glue starvation on one side resulted from slight variation in thickness of common dimension material (Fig. 6).

On the side where the glue contact was good, the unit stress on the area was 68 psi, while on the other side where failure occurred there was approximately a 25 percent contact area with a unit stress of 307 psi.

Discussion

Strain gages gave reasonably consistent readings. The increase in strains followed straight lines so that the strain at the design load was determined easily.

The stresses due to axial loads, to bending introduced by loading in top chords and to deflections of truss members, were calculated for the end of each member. Under ordinary design conditions the first two of these influences are taken into account and in this discussion are considered to be primary stresses. The third influence plus other defects in construction are not normally allowed for in computations and are considered, therefore, as secondary stresses.

The measured axial strains were obtained by averaging the strains on the four surfaces of each member. The strains caused by bending were measured as a combined strain which included bending in the top chords and the effects caused by truss deflection. These two were separated according to the ratio between the corresponding calculated values. The stresses calculated from these strains were then regrouped into primary and secondary stresses as previously described. These strains were then multiplied by the modulus of elasticity to determine the unit stress.

Stresses caused by bending in the top chords are high in most members and, when combined with axial stresses, represent a large proportion of the total stress.

Secondary stresses, the result of truss deflection, comprise a small percentage of total stress as shown in Table 1. In member U_1L_2, they were 85.0 percent; in all the other members they were 17.6 percent or less. The fact that the two usually high values do not occur at similar points in the truss, suggests that strain-gage results may be erroneous, because the actual value for strain is small at points where the percentage is so large.

These secondary stresses are high at the ends of the members in the panel points. In designing the individual members as columns, a reduction is made in the allowable unit stress depending on the "slenderness ratio". Most truss members are long and slender, so the unit stress is reduced to allow for bending at the center portion of the member. Since the secondary stresses are high at the supports, the reduction in allowable unit stress for bending allows for the added stress at the supports where the members are understressed. The combination of secondary stresses and column action tend to produce a balanced design in the member.

Conclusions

The computed values of strain check well with the measured values which indicate that the assumption of no rotation at the panel points is logical and could be used in future calculations.

When calculated bending of the top chord members of this truss is combined with the axial stress to produce primary stress, the magnitude of the secondary stress is less than 17.6 percent of the primary stress. If the allowable unit stress in members is decreased according to the standard column formula, the secondary stresses will be taken care of, because the decrease in allowable stress allows for bending at the center of the member. The secondary stresses could be neglected in design when using presently accepted factors of safety.

A design stress of 200 psi would be adequate for glue contact area and would result in factors of safety approximately the same as those used in other members in the design.

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Air Conditioning Reduces Chick Mortality

WHILE hot summer weather produces a sharp rise in chick losses, both at hatcheries and in transit, modern air conditioning has substantially reduced baby-chick mortality. This has been proved in the experience at Vineland Farms Hatchery at Vineland, N. J., where between 10 and 12 million chicks are hatched each year. Since a Chrysler Airtemp air-conditioning system was installed in the holding room of this hatchery last May, chick losses from overheating are at an all-time low; also, the percent lost in transit has been less because chicks are found to be much stronger when leaving the hatchery.

A problem on how to minimize draft was solved by using low air velocities with anemostat diffusers. Air discharge velocity from the anemostats is 500 fpm with a maximum 50 fpm 18 in directly beneath the outlets. With this system, chicks could be stacked in cartons within 18 in of the diffusers. A steam coil in the packaged air conditioner provides for the tempering of outside air in the winter. The problem of chicken fuzz was overcome through the use of a double bank of filters which are cleaned daily.

Storage Pond Design

Dwight D. Smith
Member ASAE

Recorded data from two experimental reservoirs and a study of factors relevant to water storage reveal important design information for irrigation water storage ponds

FARM reservoirs properly designed and constructed can furnish a reliable and economical supply of water for supplemental irrigation in many soil areas where adequate supplies from streams or shallow wells are not available or economically feasible. For upland areas like much of north Missouri they are the only practical source of water supply.

There are three principal factors to be evaluated in the design of farm reservoirs for an irrigation water supply. The first of the three is *(a)* the irrigation-water requirement. As for any system this includes determination of consumptive use, available moisture capacity of the soil root zone, probable soil-moisture deficits at the beginning of the season, and application efficiency. The other two factors are (*b*) evaporation and seepage losses from the reservoir and *(c)* drainage area size and probable water yield during drought cycles. With those three factors evaluated the design engineer can determine whether a one or two-year water supply reservoir is the more practical and the storage volume required.

Irrigation Water Requirement

Consumptive Use. The three generally accepted methods for determining consumptive use are Blaney-Criddle, Thornthwaite, and Penman. Solution by one of these or from experimental measurements establishes the amount of water to be provided from a combination of soil-moisture reserves, rainfall and irrigation. Experimental work in the east and midwest is supplying direct data on consumptive use for the humid region. During the drought of 1954 at the Midwest Claypan Experiment Farm near McCredie in central Missouri irrigated corn used 22 in from planting time in early May to September 1. This was at an average rate of 0.185 in per day for the 120-day period. Average daily use reached 0.37 in during midJuly. With soybeans it averaged 0.239 in per day for the same period and reached 0.51 in during midJuly.

Available Moisture Capacity. A knowledge of the available moisture capacity of a soil is necessary for determining what part of the total water requirement can be supplied from soil-moisture reserves. With a large amount of available moisture storage in the soil the storage-reservoir volume may be less. Soils such as the claypans which have an available capacity of over 8 in in the upper 4 ft will not need a surface storage reservoir as large as that required for sandy soils. Soil-moisture capacity data, as available, is generally published in irrigation guides.(1)* Recently emphasis has been placed on securing additional data of this type.

Probable Soil-Moisture Deficits. A high available soil-moisture capacity is of little value from the standpoint of reducing the size of a surface-storage reservoir if this capacity is only partially filled by rainfall between crop seasons. Deficits may be computed from climatological and water-use data. Most midwest soils have an annual moisture cycle characterized by depletion during the summer by growing crops, followed by recharge during the fall and winter. When fall and winter precipitation is appreciably below the soil-moisture capacity, planting time deficits may be expected. It is probable that not more than 50 percent of the available moisture capacity of the root zone on the higher capacity soils should be used for reduction of reservoir storage volume. A more positive figure may be secured by probability analysis of computed deficits.

Application Efficiency. This factor has been evaluated from numerous tests in the irrigation section of the country. Somerhalter (9) has reported an average measured efficiency of 84.1 percent for sprinkler and 72.4 percent for furrow (loss from end of furrow included). In general, losses during irrigation have been considered to range from 15 to 30 percent. Seventy-five or 80 percent appears to be a satisfactory application-efficiency value for design purpose for the humid region.

Evaporation and Seepage Losses

Reservoirs improperly designed and poorly constructed have large losses from evaporation and seepage. These losses may result in storage efficiencies (volume available for pumping during the irrigation season divided by total storage volume) of less than 50 percent. Rohwer (7) reports that evaporation from a copper-lined pond 85 ft in diameter averaged 70 percent of that from a standard Weather Bureau pan. He also reported a similar ratio between lake and pan evaporation.

Evaporation and seepage have been measured, beginning in 1951, from a 16-acre and a 1-acre reservoir at McCredie, Mo. The results show that evaporation from the reservoirs averaged 73 and 78 percent, respectively, of that from the Weather Bureau pan. The pan, however, was located at Columbia, 25 miles west of the reservoirs.

Losses by months from the McCredie reservoirs are plotted against the Weather Bureau pan data in Figs. 1 and 2. A linear relationship, as expressed by the following equation, was assumed:

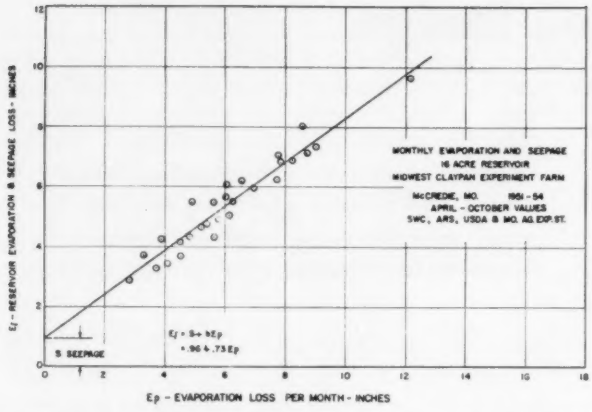
$$E_r = S + b\,E_p$$

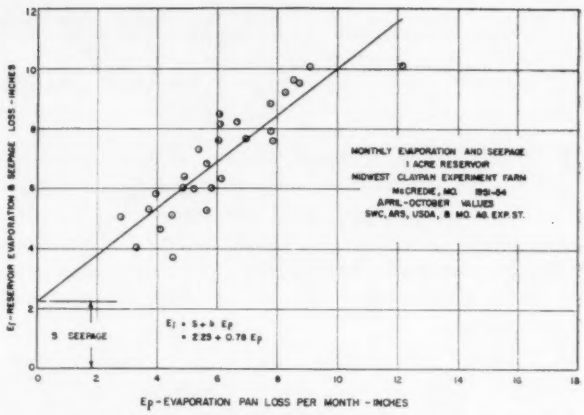
in which E_r = monthly reservoir loss in inches

Paper presented at the annual meeting of the American Society of Agricultural Engineers at Urbana, Ill., June, 1955, on a program arranged by the Soil and Water Division. Contributed as a cooperative project of the Eastern Soil and Water Management Section (SWC, ARS), U.S. Department of Agriculture and the agricultural engineering department, University of Missouri. Approved as Journal Series Paper No. 1529 of the Missouri Agricultural Experiment Station.

The author—DWIGHT D. SMITH — is agricultural engineer (SWC, ARS), U.S. Department of Agriculture, and research associate, agricultural engineering department, University of Missouri.

*Numbers in parentheses refer to the appended references.


MONTHLY EVAPORATION AND SEEPAGE
16 ACRE RESERVOIR
MIDWEST CLAYPAN EXPERIMENT FARM
McCREDIE, MO. 1951-54
APRIL - OCTOBER VALUES
SWC, ARS, USDA & MO. AG. EXP. ST.
S SEEPAGE
Ep - EVAPORATION LOSS PER MONTH - INCHES


MONTHLY EVAPORATION AND SEEPAGE
1 ACRE RESERVOIR
MIDWEST CLAYPAN EXPERIMENT FARM
McCREDIE, MO. 1951-54
APRIL-OCTOBER VALUES
SWC, ARS, USDA, & MO. AG. EXP. ST.
S SEEPAGE
Ep - EVAPORATION PAN LOSS PER MONTH - INCHES

Evaporation and seepage losses from reservoirs on the Midwest Claypan Experiment Farm, McCredie, Mo., in relation to evaporation from U.S. Weather Bureau pans • Fig. 1 *(Left)* Data from a 16-acre, clay-blanketed reservoir • Fig. 2 *(Right)* Data from a 1-acre reservoir

E_p = monthly Weather Bureau pan loss in inches

S = average monthly seepage loss in inches

b = a constant expressing the ratio of reservoir to pan evaporation loss.

S and b were evaluated by the method of least squares.

Approved construction methods for control of seepage were followed in construction of the 16-acre reservoir. This included a clay blanket over the face of the dam and other pervious soil areas in the bottom of the reservoir. The corrugated metal spillway tube of the 1-acre reservoir allows leakage through rivet holes when the water level is within 6 to 8 in of being full. This increases the seepage rate for certain months and may account for the greater scatter about the relationship line than for the 16-acre reservoir. While a core trench was installed during construction of the dam for the 1-acre reservoir no special compaction was used other than by the bulldozer used in the construction process. The 1-in-per-month seepage rate for the 16-acre reservoir is probably near a normal amount for well-constructed reservoirs. That of the small reservoir is on the excess side.

Evaporation data from Weather Bureau pans are available for most sections of the country. Evaporation may be computed also by equations such as Rohwer's (7), equation 10. Most Weather Bureau pans are operated only 7 months of the year. Losses during the remainder of the year however, are usually small. For the 16-acre reservoir at McCredie total losses averaged 2.14 in per month for the 5-month period November to March. By use of the reservoir loss equation, pan evaporation for this period was calculated to average 1.62 in per month or 26 percent of the average measured pan loss during the other 7 months of the year.

Watershed Yield

Generally farm ponds have been constructed with small drainage areas to minimize the spillway problem and to insure sanitary and silt-free water. Seldom has the ratio of drainage to pond area exceeded 5 to 1. For irrigation water-supply reservoirs, much larger drainage areas are required to insure supplies of water during drought cycles. Runoff records upon which probable yield amounts can be based are limited both in extent and in duration. For Missouri, records are available for two soil types, both record periods including a drought cycle.

Runoff records were secured on the Shelby silt loam area of northwest Missouri during the 10-year period 1932-41. The soil is of glacial origin and is classified as moderately permeable. The runoff amounts from a well-managed bluegrass pasture watershed and from a terrace area in cultivated crops, both approximately 5 acres in size, were averaged to simulate the runoff from a mixed-cover watershed. The acreages of pasture and cultivated crops average about equal on farms in this soil area.

The single storm runoff amounts were totaled for each water year (July 1 to June 30) and plotted on logarithmic probability paper. Plotting points were from a table presented by Beard (2). A linear relationship on log probability paper was assumed. A trend line was fitted to the data by the method of least squares. Logarithms of runoff amounts and plus or minus horizontal linear measurements from the 50 percent line to each of the percent of time plotting points, were used for the two ordinates. Fig. 3 shows the data for the Shelby soil. Runoff amounts for two consecutive water years were also computed and plotted on the figure. The plottings for both the single and the 2-year runoff amounts show a definite linear relationship. The minimum single-year runoff during the 10-year period was 0.39 in. It occurred during the year ending June 30, 1938. According to the trend line an amount this low could be expected to occur once in 25 years.

Runoff records from a 154-acre mixed-cover watershed in the Mexico silt loam area of central Missouri were secured during the 13-year period 1941-54. The soil is a claypan classified as slowly permeable. The runoff amounts were plotted as described for Shelby soil data and presented in Fig. 4. Runoff from the Mexico soil watershed does not fit a linear relationship as satisfactorily as that from the Shelby area. The extremely low runoff of 0.21 in for the water year ending June 30, 1954, steepened the trend line such that the line does not appear to represent the true trend of the data. The trend line does indicate, however, that an amount this small could be expected once in 1000 years.

Minimum 1 and 2-year amounts of runoff that may be expected during different time periods were read from the

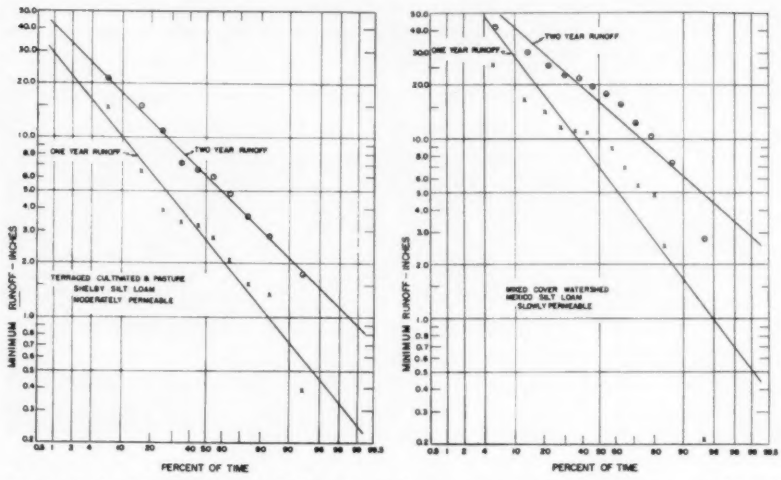


Fig. 3 *(Left)* Water-year runoff for one and two consecutive years from a moderately permeable area for the 10-year period, 1932-41 • Fig. 4 *(Right)* Water-year runoff for one and two consecutive years from a slowly permeable area for the 13-year period, 1941-54

curves of Figs. 3 and 4 and tabulated in Table 1. These values may be used in determining size of watersheds on similar soil and climatic areas required to fill irrigation water supply reservoirs during drought cycles. Since both records were secured during a period of limited length containing a drought cycle the tabulated values may be considered conservative for design purposes.

TABLE 1. MINIMUM WATER YEAR AMOUNTS OF RUNOFF TO BE EXPECTED DURING DIFFERENT TIME PERIODS FOR SOILS OF TWO PERMEABILITY CLASSES

Return Period	Moderately permeable Shelby silt loam		Slowly permeable Mexico silt loam	
	1 year	2 years	1 year	2 years
Years	Inches	Inches	Inches	Inches
10	0.71	2.15	1.64	6.10
25	0.43	1.46	0.97	4.30
50	0.32	1.14	0.69	3.43
100	0.24	0.91	0.51	2.80

Selecting Size of Reservoir

Recommendations for size of reservoirs are stated generally in terms of acre-feet storage per acre to be irrigated. Several of the general recommendations are as follows:

Larson (5)	1.00 acre-feet per acre.
Ruby (8)	1.50 acre-feet per acre.
Beasley (3)	1.25 to 1.75 acre-feet per acre.
University of Illinois (4)	1.50 to 2.00 acre-feet per acre.

The latter two vary the size depending upon the irrigation requirement for different soils. For a specific case, refinement can be made depending upon evaporation, seepage, surface area, and whether the design is based on holding a 1 or 2-year supply. Table 1 shows that minimum runoff for 2-year periods are at least three times that of the 1-year amounts. Evaporation and seepage losses will be higher for a 2-year supply because of the larger average surface area during the first year. With a 1-year supply reservoir the volume need be large enough to hold only the irrigation requirement plus evaporation and seepage during the irrigation season. But for a 2-year supply the volume must be two times the single-year supply plus the increased loss during the first irrigation season because of the larger area and plus the between season losses.

If an irrigation requirement of 400 acre-inches is assumed for the period July through September, a total storage volume of 555 acre-inches will be required, if it is to be stored in a reservoir with the storage-depth relationship of the 16-acre McCredie reservoir. Evaporation and seepage minus rainfall during the 3-month period was assumed to be 14.4 in. This was the 3-month average net loss for the 16-acre McCredie reservoir during 1953 and 1954. Without the direct measurement it could have been estimated by the reservoir loss equation and Weather Bureau pan data. For this reservoir a water depth of 10.0 ft and a surface area of 10 acres would be required to hold the 555 acre-inches. But with only this amount of storage the reservoir would be empty at the end of the irrigation season. For the supply to be replenished before the next season, runoff would have to equal the 555 acre-inch storage plus an additional 55 acre-inches for the net loss during the 9-month period, October to June. For 24 out of 25 years this would require a claypan soil drainage area of 630 acres. But for two consecutive drought years like 1953-54 there would have been no water for irrigating during 1954.

A reservoir similar to the one in the previous illustration, but with the dam of sufficient height to hold a 2-year supply, would require a storage volume of 1240-acre-inches. The depth of water would be 14.5 ft and the surface area 15.75 acres, the same as the McCredie reservoir. A claypan drainage area of about 290 acres would be required to supply 1240 acre-inches of runoff during a 2-year period with the minimum amount of runoff to be expected 96 percent of the time. The reason a smaller drainage area is required for a 2-year supply reservoir than for a 1-year supply reservoir, is the fact that 4.4 times as much runoff can be expected during two consecutive years than during a single year for a 25-year return period and a drainage area of claypan soil. This is shown in Table 1.

A breakdown of the losses by periods for the 1 and 2-year supply reservoirs are shown in Table 2. Depth-area and depth-volume curves for the 16-acre McCredie reservoir were used in making these determinations. The monthly rainfall and reservoir losses that were used in the analysis are shown in Table 3.

TABLE 2. EVAPORATION AND SEEPAGE LOSSES AND CORRESPONDING RESERVOIR DEPTHS BY PERIODS FOR 1 AND 2-YEAR SUPPLY RESERVOIRS, WITH STAGE-VOLUME RELATIONSHIP OF THE 16-ACRE RESERVOIR AT McCREDIE

Supply period	Irrigation		Net Loss† During irrigation Season		Between seasons		Total	
	Depth, ft	Vol., ac-in	Depth, ft	Vol., ac-in	Depth, ft	Vol., ac-in	Depth, ft	Vol. ac-in
One year	8.8	400	1.2	155	—	—	10	555
Two years								
1st year	2.5	400	1.2	190	—	—	3.7	590
2nd year	8.8	400	1.2	155	0.8	95	10.8	650
Total	11.3	800	2.4	345	0.8	95	14.5	1240

†Evaporation plus seepage minus rainfall. Irrigation season assumed to be July 1 to September 30.

The storage capacity of the 1-year supply reservoir was increased nearly 40 percent to provide for evaporation and seepage losses but with the 2-year supply reservoir an increase of 55 percent was required. The storage efficiencies of the reservoirs are 72 and 65 percent, respectively. If the reservoir side slopes had been steeper the net loss (Table 2) storage volume would have been less.

The annual irrigation requirement of 400 acre-inches assumed in the illustration is sufficient for 16 acres of corn and 16 acres of pasture during severe drought conditions as experienced during 1953 and 1954 at McCredie. The 1-year storage volume is equivalent to 1.45 acre-feet storage per acre to be irrigated and the 2-year supply reservoir 3.23 acre-feet per acre to be irrigated. For the 1-year supply 20 acres of drainage area would be required per acre to be irrigated, but for the 2-year-supply reservoir it would require only 9 acres. With soil such as the Shelby, larger drainage areas per irrigated acre would be required. Both the storage volume and the drainage area per irrigated acre would be less with a reservoir with steeper side slopes.

TABLE 3. EVAPORATION AND SEEPAGE BY MONTHS FROM THE 16-ACRE RESERVOIR AT McCREDIE AND MONTHLY RAINFALL AMOUNTS FOR THE DROUGHT YEARS OF 1953 AND 1954

	1953		1954	
Month	E+S	Rainfall	E+S	Rainfall
January	1.19	1.42	0.92	0.71
February	2.09	1.01	1.64	0.72
March	2.60	3.60	2.81	1.99
April	3.70	2.95	4.33	3.58
May	5.55	3.74	2.02	3.62
June	7.34	3.50	6.23	2.45
July	7.17	1.96	9.61	0.20
August	7.06	2.14	5.94	5.33
September	6.91	2.38	6.09	1.93
October	3.46	2.72	3.72	4.72
November	3.02	0.60	2.00	1.04
December	2.75	0.71	1.13	1.52
Total	52.84	26.73‡	49.44	27.81‡

‡Normal annual rainfall 39.01 in.

Reservoirs with steeper side slopes and increased depth are more efficient in storing water because of the smaller area for evaporation and seepage. To illustrate this point, reservoir stage-volume curves were prepared for round reservoirs with side slopes of 5, 10 and 20 percent, all with a bottom area of two acres. Increasing the side slopes from 5 to 20 percent reduced the storage volume required to hold the losses by half. The results are shown in Table 4. This is an important point to consider in reservoir design. However, it is recognized that steep side slopes are impractical for the larger reservoirs on areas with gently rolling to moderate land slopes because of excessive amounts of soil that must be excavated.

TABLE 4. EFFECT OF RESERVOIR SIDE SLOPE ON STORAGE VOLUME REQUIRED TO HOLD EVAPORATION AND SEEPAGE LOSSES

	Reservoir side slope (2-acre bottom)		
Item	5 percent	10 percent	20 percent
1-year supply			
Loss volume	100 ac-in	80 ac-in	50 ac-in
Loss as percent of use*	25 percent	20 percent	12½ percent
Storage efficiency	80 percent	83 percent	89 percent
Total depth	8.5 ft	10.9 ft	13.6 ft
2-year supply			
Loss volume	360 ac-in	240 ac-in	170 ac-in
Loss as percent of use*	45 percent	30 percent	21 percent
Storage efficiency	69 percent	77 percent	82 percent
Total depth	13.5 ft	17.6 ft	22.1 ft

*Use volume 400 acre-inches per season.

Summary

1 The three factors to be evaluated in design of farm reservoirs for an irrigation water supply are: *(a)* irrigation requirement per year, *(b)* evaporation and seepage losses from the reservoir, and *(c)* drainage-area size and watershed yield.

2 Evaporation losses from a 16-acre reservoir has averaged 73 percent of that from a standard U. S. Weather Bureau pan during the last 4 years, and 78 percent from a 1-acre pond.

3 Seepage from a clay-blanketed reservoir 16 acres in size has averaged 1 in per month, and 2¼ in per month from the 1-acre pond without the blanket.

4 Evaporation and seepage losses for the 16-acre reservoir, minus rainfall during the drought years of 1953-54, totaled 24 in per year of which one-half was seepage.

5 The amount of runoff to be expected from a slowly-permeable claypan-soil watershed 24 out of 25 years is 1 in or more but for two consecutive years the amount is 4.3 in or more.

6 The amount of runoff from a watershed with moderately permeable soil was less than half that from a watershed with the slowly permeable soil.

7 A reservoir with capacity for a 2-year supply is needed to insure an adequate supply during drought cycles.

8 For a 1-year supply reservoir 20 acres of claypan-drainage area are needed per acre to be irrigated to insure a supply 24 out of 25 years, but only 9 acres for a 2-year-supply reservoir.

9 Storage volume per acre to be irrigated should be 1½ acre-feet per acre for a 1-year supply reservoir and 3¼ acre-feet for a 2-year supply reservoir on midwest claypan soils.

10 Reservoir storage volume required to hold the quantity of water that will be lost through evaporation and seepage may be reduced by 50 percent by steepening the average side slopes from 5 to 20 percent.

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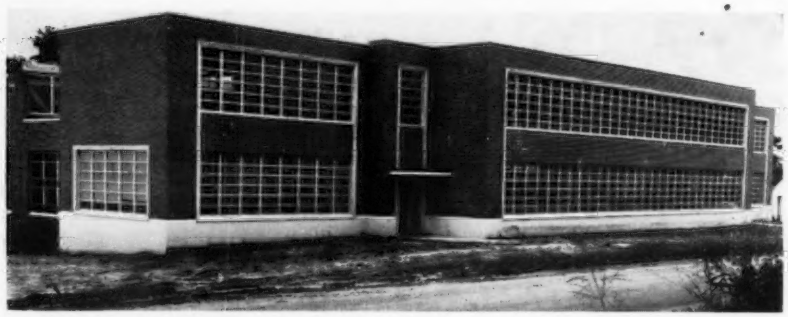
NEWS SECTION



The new agricultural engineering building at the University of Florida dedicated on October 15

New Florida Ag Engineering Building Dedicated

THE University of Florida dedicated its new agricultural engineering building on Saturday, October 15. The dedication ceremony climaxed a two-day meeting of the Florida Section of ASAE. Wayne H. Worthington, ASAE president, spoke on the contributions of agricultural engineering to the national agricultural program. The dedicatory address on the development and place of agricultural engineering in the agricultural program of the University of Florida was given by Willard M. Fifield, provost for agriculture. Frazier Rogers, head of agricultural engineering department, expressed appreciation on behalf of the faculty of the department of agricultural engineering.

Construction of the new building began in June 1954, and was completed in July 1955. Its 38,000 square feet of floor space is subdivided into four large modern classrooms, 14 offices, eight laboratories, a seminar room, a student drafting room, an extension drafting room, a conference and library room and two filing and supply rooms.

The office and classroom section is a two-story structure and the laboratory section is a single-story structure under a sawtooth-type roof. The laboratories are equipped with both single and three-phase electric current, underground carbon dioxide exhaust ducts, underground floor drains, low-pressure live steam outlets, compressed air outlets, hot and cold water, welding booths with forced ventilation, and an underground water reservoir with 10,000 gallons capacity for use in problems associated with water control.

Facilities are provided for agricultural engineers in extension, research and teaching to perform their respective duties in all branches of agricultural engineering—power and machinery, farm structures, rural electrification, soil and water control, and crop processing.

National Dairy Engineering Conference, March 13 and 14

THE Fourth Annual National Dairy Engineering Conference will be held March 13 and 14 at the Kellogg Center, Michigan State University, East Lansing. Suggestions for speakers may be sent to Carl W. Hall, agricultural engineering department, Michigan State University.

Tile Drainage Committee Invites Suggestions

AN OPEN meeting of the ASAE Committee on Specifications for the Design and Construction of Tile Drains, during the Winter Meeting of the Society in December, has been announced by K. H. Beauchamp, chairman. Interested persons are invited to attend prepared to comment and offer suggestions for revision of the tentative specifications published in the 1955 edition of *Agricultural Engineers Yearbook* (pages 117-126). In view of the fact that these specifications have been in publication for two years, the Committee expects some suggestions to result from experience in their application, and from the results of recent research. The exact time and place of the meeting will be announced at the Soil and Water Division program sessions.

Southern Agricultural Workers Meet February 6 to 8

THE 53rd annual meeting of the Association of Southern Agricultural Workers will be held in Atlanta, Ga., February 6-8. Eight sections will meet in the Atlanta Biltmore Hotel and the remaining five sections and the Cotton Improvement Conference will meet in the educational building of the First Baptist Church.

A general session of the entire convention will be held on Monday, February 6, at 11:00 a.m. in the Biltmore Hotel. The second general session will be on Wednesday, which will consist of program reports, the presidential address and a short business meeting.

ASAE Meetings Calendar

November 18 — OKLAHOMA SECTION, Student Union, Oklahoma A&M College, Stillwater

December 8 — CONNECTICUT VALLEY SECTION, University of Massachusetts, Amherst.

December 12 to 14 — WINTER MEETING, Edgewater Beach Hotel, Chicago

December 29 and 30 — PACIFIC COAST SECTION, Tucson, Ariz.

February 6-8—SOUTHEAST SECTION, Atlanta, Georgia

June 17-20—49TH ANNUAL MEETING, Hotel Roanoke, Roanoke, Va.

NOTE: Information on the above meetings, including copies of programs, etc., will be sent on request to ASAE, St. Joseph, Mich.

New Federal Service Entrance Examination

THE U.S. Civil Service Commission, has announced major changes in its college-level recruitment program. A number of civil service examinations previously open at the college level have been consolidated into a single Federal Service Entrance Examination. Under this new program, a student will be required to take only one examination which will be appropriate for the great majority of the entrance level positions in the federal service. Persons who pass the examination will be considered for a variety of positions suited to their interests, aptitudes, training, and capabilities.

Interested persons may obtain copies of the examination announcement and application forms from the U.S. Civil Service Commission, Washington 25, D.C.

International Irrigation and Drainage Meeting

AN ANNOUNCEMENT has been received that the International Commission on Irrigation and Drainage will hold its next meeting in this country in May, 1957. The probable meeting place will be San Francisco. It is proposed that papers be presented by men from various countries, including the United States. Four subjects have been selected for discussion, as follows: canal lining, soil-water relationships in irrigation, hydraulic structures, and interrelationship of irrigation and drainage.

Persons interested in participating or attending should contact W. E. Blomgren, chairman, executive committee, U.S. National Committee, International Commission on Irrigation and Drainage, 260 Leetsdale Dr., Denver 22, Colo.

Agricultural Pipe Association Convention

THE American Concrete Agricultural Pipe Association, 228 N. LaSalle St., Chicago 1, Ill. (Howard F. Peckworth, managing director), announces that the 6th annual convention of the Association will be held at the Brown Palace Hotel, Denver, Colo., April 12 to 14, 1956.

Research Projects in Agricultural Engineering

(EDITOR'S NOTE: This list of active research projects supplements the lists published in the June and August issues of AGRICULTURAL ENGINEERING.)

Rutgers University, New Brunswick, N. J.

Development of Structures and Allied Equipment for Processing; Storage and Self-Feeding of Forage to Cattle. 1948 (1954)

Engineering Investigations in the Harvesting, Curing and Storage of Hay, with Particular Reference to Artificial Drying. 1948 (1954)

Basic Space Requirements for Northeastern Farm Houses as Influenced by Household Activity Patterns. 1947 (1954)

The Development of a Suitable Electrical Moisture Meter to Determine the Moisture Content of Forage and Grains in the Field. 1948 (1954)

Grain Storage and Conditioning. 1954

ASAE MEMBERS in the News

James H. Bornzin has been promoted to the position of assistant division chief engineer, farm implement division, International Harvester Co., at the company's main office in Chicago. He was previously assistant chief engineer at the company's Memphis, Tenn., works.

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Clarence R. Fahnestock has resigned as agricultural engineer at the Alaska Agricultural Experiment Station, Palmer, to accept a position in the research department of the Caterpillar Tractor Company at Peoria, Ill.

•

John Heilman has resigned from the position of executive director of Consejo de Bienestar Rural, at Caracas, Venezuela, to assume the position of president of the consulting firm, Desarrollo Industrial Agricola, C. A. in Caracas.

•

Morris E. Schroeder, until recently on duty with the armed services, is now employed as instructor in agricultural engineering extension at Pennsylvania State University, University Park.

•

Floyd V. Matthews, Jr., has resigned his position in the product engineering dept., Richmond Works, International Harvester Co., to accept appointment on the agricultural engineering staff of the University of Maryland, College Park.

•

Robert T. Scott has been named public relations director for Hanson & Shea, Inc., trade association management specialists of Pittsburgh. Prior to accepting his new position, Mr. Scott was with the Westinghouse Electric Corp. information services department where he handled school and electric utility public relations programs. His work was closely related with youth activities. In addition to public relations work for trade associations, trade shows and industrial concerns, his new job will permit him to devote some time to public relations work pertaining to farm youth activities.

•

Wesley J. Wankel, formerly technical officer on surveys, P.F.R.A., Saskatchewan, has accepted a position with the Saskatchewan Department of Agriculture.

•

Elijah L. Thomas, Jr., after completing requirements for an M.S. degree at the University of Arkansas, has accepted a position on the engineering staff of the Boeing Airplane Co., Wichita, Kans.

•

John F. Mellen, formerly with the Waialua Agricultural Co., Waialua, Hawaii, has joined the Caterpillar Tractor Co., in the capacity of an export sales trainee. His new address is 332 Laurel St., Morton, Ill.

•

Charles N. Hinkle, upon return from military service, has accepted a half-time teaching assistantship at the University of Missouri. His new job will permit him to work for a Ph.D. degree.

•

Lee C. Bowden has accepted a position as designer in the air conditioning department of General Electric Co., Louisville, Ky. He was formerly in the employ of the Avery Div., Minneapolis-Moline Co., in that city.

Philip H. Wilson, formerly district agricultural engineer for New York State College of Agriculture, has been appointed as head of the mechanized agriculture department and extension specialist in agricultural engineering, college of agriculture, University of Rhode Island, Kingston.

•

LeRoy C. Nelson, who has been employed as a farm manager at Mount Valley, Kans., has accepted a position as area extension agricultural engineer for Kansas State College and will be located at Garden City, Kansas.

•

Ralph C. Prince has resigned as an instructor in agricultural engineering at the University of Tennessee to accept a similar position in the agricultural engineering department of Pennsylvania State University at University Park.

•

Warren L. Roller has resigned as an instructor in agricultural engineering at Purdue University to join the agricultural engineering staff of Ohio State University, Columbus.

•

Richard R. Russell, a 1950 agricultural engineering graduate, has completed the aircraft maintenance officer's course at Chanute Air Force Base in Illinois and is now a maintenance officer at the Tinker, Okla., Air Force Base.

•

Jerles E. Russell, formerly with Allis-Chalmers Mfg. Co., Milwaukee, has accepted a position with the U.S. Soil Conservation Service. His headquarters will be at Huntsville, Ark.

NECROLOGY

Robert M. Salter, chief of the Soil and Water Conservation Research Branch (ARS), U.S. Department of Agriculture, died at his home in Silver Spring, Md., September 13.

Born at Huntington, Ind., in 1892, Mr. Salter received a B.S. degree in 1913 and an M.S. degree in 1914 from Ohio State University. His major was in chemistry and agronomy. In 1944 he received an honorary doctor of science degree from Rutgers University. He became a soil chemist at West Virginia University and its agricultural experiment station in 1915. In 1919 he became head agronomist. He returned to Ohio State University and the agricultural experiment station as professor of soils extension in 1921 and became acting head of the soils department in 1924. From 1925 to 1940 he was chief in agronomy at the Ohio Agricultural Experiment Station, and chairman of the agronomy department at Ohio State University from 1929 to 1940. He served as director of the North Carolina Agricultural Experiment Station 1940 and 1941.

Mr. Salter joined the U.S. Department of Agriculture in 1941, at which time he became head of the division of soil and fertilizer investigations, Bureau of Plant Industry. In 1942 he became chief, Bureau of Plant Industry, Soils, and Agricultural Engineering. From 1951 to 1953 he was chief of the Soil Conservation Service. Since November, 1953, he served as chief of the soil and water conservation branch, Agricultural Research Service.

He is survived by his widow, two sons and two daughters.

With the ASAE Sections

Oklahoma Section

A meeting of the Oklahoma Section will be held at the Student Union, Oklahoma A & M College, Stillwater, November 18. Papers and reports planned for the meeting include such subjects as conditioning grain in terminal storage, the use of window refrigerated air conditioners for egg cooling, runoff studies and related work being done at the outdoor hydraulic laboratory near Stillwater, and organizing a farm water systems campaign.

M. R. Lohmann, new dean of the school of engineering, Oklahoma A & M College, will be the featured speaker for the noon luncheon. On the afternoon program is included a laboratory inspection trip to observe some of the agricultural engineering research projects that are underway. For those who would like to see the latest in milking parlors, a short trip will be made to the dairy farm to observe the new type of milking parlor that is designed for one-man operation.

Washington Section

A meeting of the Washington Section will be held Friday, November 18, in Room 6970, South Building, USDA, 14th and Independence Ave., S.W., Washington, D.C.

Harold E. Pinches, assistant director, Farm and Land Management (ARS), USDA, will talk on management engineering in agriculture. Mr. Pinches is former head of agricultural engineering at the University of Connecticut. E. G. McKibben will serve as chairman.

The change in time and place from the normal meeting schedule was brought about because of the Armistice Day holiday.

At a section meeting held October 14, Harry A. Borthwick, newly elected president of the American Society of Plant Physiologists, spoke on the subject of regulatory effects of light on plants. T. E. Hienton, head, rural electrification section, agricultural engineering research branch, USDA, served as chairman.

Chicago Section

E. B. Scott, division manager of agricultural sales, Public Service Co. of Northern Illinois, has been elected as the new chairman of the Chicago Section at the Oct. 17 meeting. Mr. Scott succeeds K. W. Snyder. G. A. Karstens, Dan Kitchen, and R. W. Whitaker have been elected as vice-chairmen. E. R. Johnson will serve as secretary-treasurer for the coming year.

Appointments for the planning of the ASAE Winter Meeting include Dan Kitchen, publicity; G. A. Karstens, visual aid equipment, and E. R. Johnson, registration and information.

Connecticut Valley Section

A meeting of the Connecticut Valley Section will be held December 8, at the University of Massachusetts, Amherst, with a supper at 6:30 p.m. in the university commons. Speaker for the evening will be Harold E. Gulvin, formerly head of agricultural engineering, University of Rhode Island, and now head of the farm products research division, Eastern States Farmers' Exchange. Mr. Gulvin will preview his new book on "Mechanized Agriculture".

Other items of interest will include the secretary's and executive committee's reports and election of officers for the coming year.

CHAIN is important to the good name of your machine...

ANY SHORTCOMING in machine performance —whatever the cause—reflects on the maker. That's why so many farm machinery manufacturers standardize on Link-Belt chain for long life and added dependability. Exact manufacturing controls and thorough testing assure maximum chain strength and uniformity . . . contribute to the overall quality of your machine.

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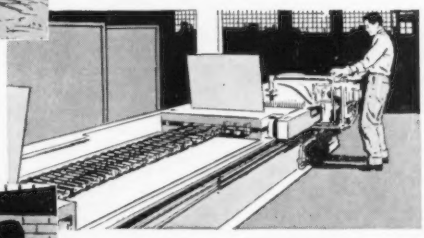
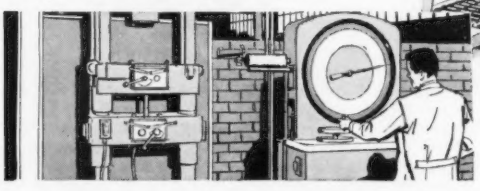
COMPLETENESS ASSURES LOW-COST, PRACTICAL ANSWERS. With Link-Belt's broad lines of chain, sprockets and attachments, farm machinery manufacturers are sure to find the right answer for each application.

EXPERT ENGINEERING AND FIELD TESTING. Link-Belt's engineering staff is unequalled in ability and experience. Design innovations are continually recommended and thoroughly field-tested. Many universally-used chain developments were born at Link-Belt.



ACCURATE MANUFACTURE. In the world's largest chain plant — modern, specialized machines allow the economies of large-scale production without sacrificing accuracy. In addition, continuous inspection safeguards tolerances and finish of every length of chain. Next time you face a drive or conveying problem, call your nearest Link-Belt office.



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CHAINS and SPROCKETS

LINK-BELT COMPANY: Executive Offices, 307 N. Michigan Ave., Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office, New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville, N.S.W.; South Africa, Springs. Representatives Throughout the World. 13,717

NEW PRODUCTS CATALOGS

New 5-Plow Diesel Tractor

Deere & Co., Moline, Ill., has announced a new 5-plow standard-tread diesel tractor. It is the new Model 80 Diesel, successor to the Model R.

This tractor reportedly will plow a 6-ft strip, pull a 21-ft double-action disk harrow, and will handle double hookups of hydraulically controlled grain drills, tool carriers, field cultivators, rod weeders, and comparable loads.

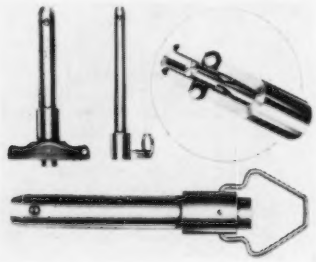
In factory tests, the new tractor developed approximately 65 hp on the belt, 57 hp on the drawbar, and matched the fuel consumption of the Model 70 Diesel. Built-in power steering, live hydraulic Powr-Trol, and live power shaft are available as optional equipment. The hydraulic system features a dual valve, which permits independent or simultaneous operation of two remote cylinders.

For starting, especially in cold weather, a V-4 gasoline starting engine is used. This engine furnishes power to crank the diesel, warms the liquid in the connected cooling systems, and also preheats incoming air for earlier starting.

New Lock Pin

D. W. Price, 11161 West Pico Blvd., Los Angeles 64, Calif., has introduced a new safety lock and release pin. Called the Ball-Lok pins, they are made to military specifications and are of single-action type —either push or pull. No push-type pin can be released accidentally. The release button must be depressed to disengage the lock at the time the pin is pulled. Remote control models are produced also.

When the pin is inserted, or in a locked position, chrome steel balls protrude be-

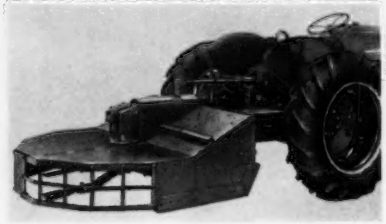


yond the body assembly, where they are locked by the large diameter of the spring-loaded plunger. To release the pin, pushing the release button (except remote control models) allows the balls to sink below the diameter of the body assembly, leaving the pin free to be inserted or removed. Models which may be mallet driven are provided also. Pins are available in a range of 8 models in 16 sizes. Distribution is by Rowe Sales Co., 2140 Westwood Blvd., Los Angeles 24, Calif.

New Rotary Cutter

International Harvester Co., 180 North Michigan Ave., Chicago 1, Ill., has introduced a new PTO-driven rotary cutter that cuts and shreds cotton and corn stalks, clips pastures, and maintains roadsides.

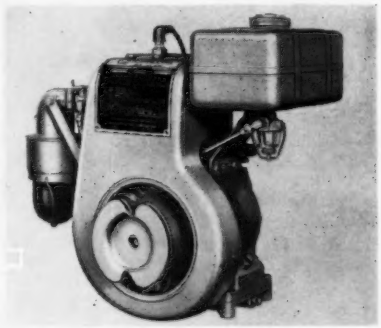
Heavy, free-swinging knives, rotating at speeds up to 120 mph, cut a 57-in swath. The high, tapered front end opening allows knives to cut 6-ft stalks as they emerge



from under the tractor and compresses the cut material for shredding. Cutting height adjusts from 3 to 14 in. Safety shields give both machine and operator protection. A special shredding attachment can be obtained to reduce stalks, weeds, or brush to a pulp-like mulch. This new cutter is available in Farmall-mounted models or trailing models for any 2-plow or larger tractor.

New Air-Cooled Engine

Wisconsin Motor Corp., Milwaukee, Wis., has announced production of the Model BKN, a 4-cycle, single-cylinder, air-cooled engine. The new engine is rated from 3.2 to 6.8 hp in a speed range of 1600 to 3600 rpm. Its 2⅞-in bore by



2¾-in stroke provides a displacement of 17.8 cu in.

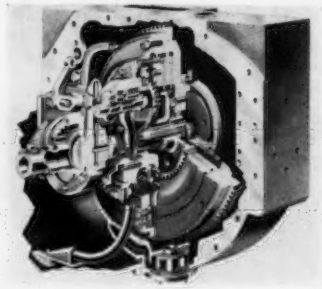
The new model can be furnished with various gear reductions, clutch assembly, electric starter and generator or starter only, and can be equipped to operate on kerosene, butane, propane or natural gas although regularly supplied for operation on gasoline.

New Clutch Set Catalog

Accurate Parts Mfg. Co., 1600 S. Ashland Ave., Chicago 8, Ill., has released a completely revised catalog listing of all its clutch sets, clutch plates and pressure assemblies. The new catalog contains 40 pages of illustrations and alphabetical lists of all clutch sets for popular passenger cars and trucks. It also lists component parts in each set which may be ordered from the catalog.

Oil Clutch for Tractor

Caterpillar Tractor Co., Peoria, Ill., has announced a new oil clutch, now available as an attachment for its D4 tractors, and similar in design to the oil clutches in the



D6, D7, D8 and D9 tractors. It features metallic-faced clutch disks, a self-contained gear-type pump and oil supply clutch brake for easy gear shifting.

The three metallic-faced plates on the new clutch are separated by oil films at all times except for the last revolution or two as the clutch is engaged. The oil system includes an oil pump with screened inlet and passages which carry oil to all parts of the clutch. Oil enters the inner diameter of the clutch plates and circulates between them by means of grooves in the clutch facings.

All-Purpose Speedometer

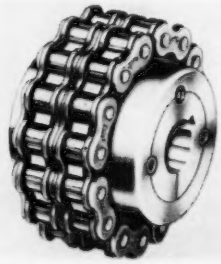
O. W. Kromer Co., 1120 Emerson Ave. N., Minneapolis 11, Minn., has introduced a new field speedometer for precise acreage application checks on all farm jobs.

The new speedometer can be used to run on the ground or off a smooth tire. It comes complete with a drawbar hitch. The unit can be attached to all types of farm equipment and gives measurement in 10ths and 100ths of a mile and registers all speeds from 0 to 10 mph. It has a Stewart-Warner head and rubber-covered rust-resistant cable.

Taper-Lock Chain Couplings

Dodge Manufacturing Corp., Mishawaka, Ind., has added taper-lock chain couplings to its line of taper-lock sprockets and roller chain.

The new chain couplings are of a flexible type and are said to permit sufficient



relative movement between the hubs to accommodate slight angular and parallel shaft misalignment.

Features of the new couplings include taper-lock bushings. These bushings are available in desired sizes — no reboring is required. The chain is a double-width, standard precision chain. Quick disconnecting of the shafts is possible by removing the one coupling pin and unwrapping the chain from the hubs.

(Continued on page 752)

Thanks . . .

for the air,
and the water,
and the generous earth . . .

for the miracle of seed,
the promise of blossom,
and the nourishment of fruit.

Thanks . . .

for the dawn,
and the pursuing twilight . . .

for rain,
and snow,
and the glory of the ever-changing year.

Thanks . . .

for music,
and art,
and poetry . . .

for commerce,
and industry,
for invention and achievement.

Thanks . . .

for the steeple,
and the town hall . . .

for the dome of authority,
and the pillar of justice.

Thanks . . .

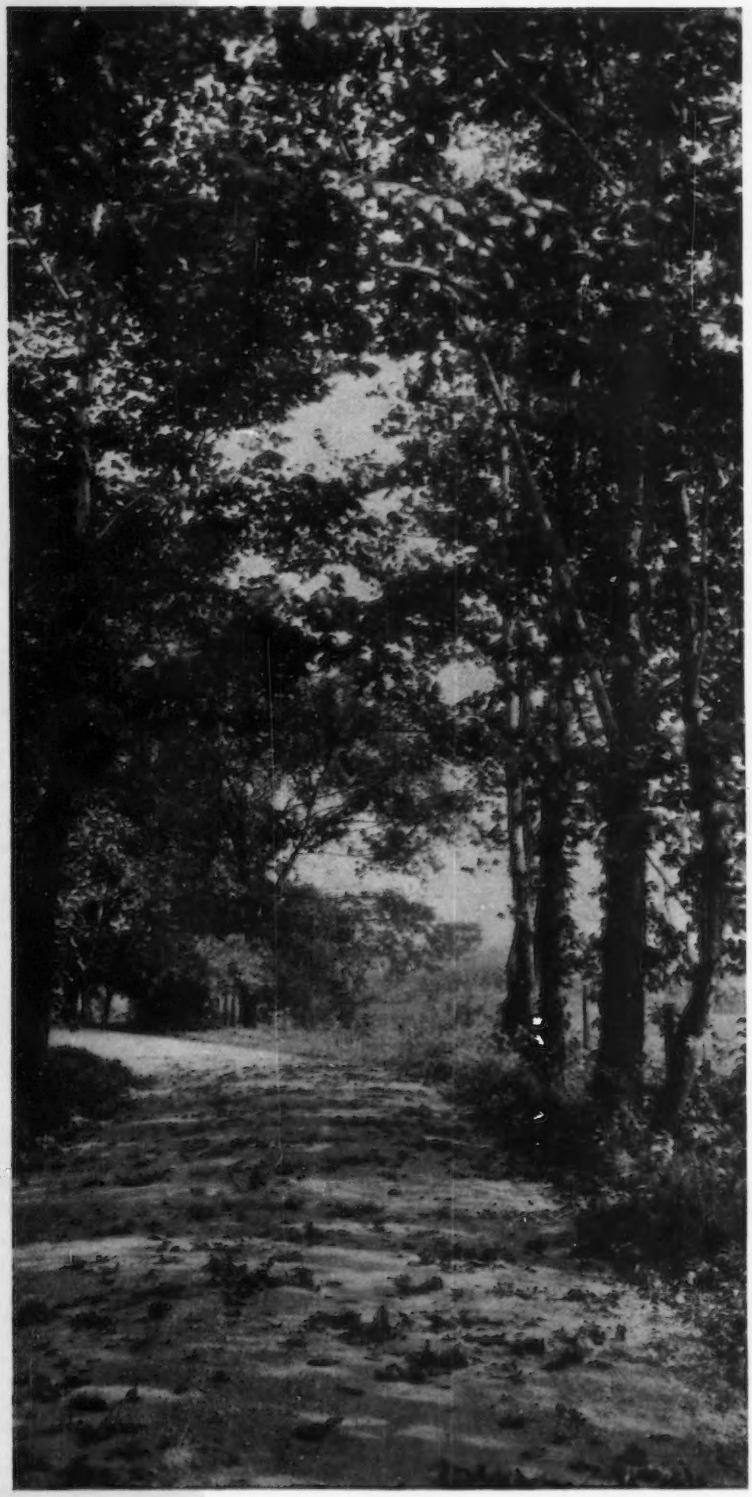
for kin,
for friend,
for neighbor . . .

for the strength of man,
the courage of woman,
for the confidence of the young,
and the wisdom of the old.

Thanks . . .

for the mind to know,
the eyes to behold,
the hands to use,
and the soul to enjoy
all these things . . .

and for the heart to say—
Thanks!



JOHN DEERE

New Products and Catalogs

(Continued from page 750)

Ductile Iron Booklet

The International Nickel Co., Inc., Reader Service Station, 67 Wall St., New York 5, N. Y., has announced a revised edition of a booklet, entitled Ductile Iron, the Cast Iron that Can Be Bent. The 28-page booklet is made up of tables, charts and photos to give up-to-date information on ductile cast iron. Photos show applications of ductile iron castings produced and used in the U.S. Added feature is a listing of typical applications in various industrial fields.

Electrall in Production

International Harvester Co., 180 N. Michigan Ave., Chicago, has announced that the Electrall, first announced in June, 1954, as

an experimental tractor-mounted electric generating and distribution system for use anywhere beyond the high line, is now in production and available at dealers. Mounted on a Farmall 400 or International W 400 tractor, the unit supplies 60-cycle power, single and three phase, for both 115 and 220-v motors, tools and appliances. It will operate a specially-designed 10-hp motor for powering hay baler, small combine and similar machines.

With a double-pole switch installed next to the high line meter, it can be plugged in to supply power for the farm home and essential barnyard equipment such as pumps and milking machines, supplying emergency stand-by power. The unit is readily attached to the tractor. Except for such front-mounted equipment as cultivator and loader, it does not interfere with normal tractor operations.

New Corn Sheller

Deere & Co., Moline, Ill., has introduced its new No. 71 corn sheller. Portable and PTO-driven to save staking and aligning a

belt, it reportedly shells up to 500 bu of ear corn per hour.

A large-area cleaning shoe, plus two blast fans, provides good cleaning of corn. A grated cob stacker separates shelled corn from cobs. An all-steel shelling unit with full circumference cage shells all the way around its inside diameter.

125-Bushel PTO Spreader

J. I. Case Co., Racine, Wis., has announced its first PTO spreader, the new Case 125. The spreader box has double-

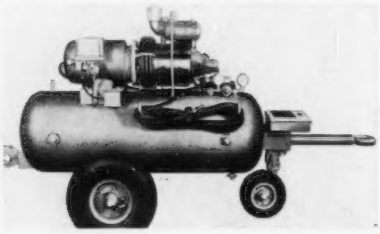
bolted, double-treated pine boards and heavy acid-resistant angle steel for reinforcement and side rails.

Basic strength stems from two beams of 5-in channel steel. The beams meet to form the V-type drawbar while extending well under the box. A single lever control handy to the tractor operator permits a choice of four rates of application. The apron conveyor and beater actions can be operated independently for cleanout convenience.

The shielded PTO is equipped for vertical adjustments to prevent binding action when used with tractors of varied PTO height. A safety jump clutch is included.

Compressor Uses Automatic Clutch

Mercury Clutch Division, Automatic Steel Products, Inc., 1201 Camden Ave. S.W., Canton 6, Ohio, has announced that



the Davey Compressor Co., Kent, Ohio, is using the Mercury automatic clutch on several models of its Hydrovane compressor and on its small reciprocating compressors powered by 2, 3 and 5-hp electric motors and 3 to 6-hp gasoline engines.

The Mercury clutch allows the power sources to reach full operating speed before the load is engaged. It enables the engine to idle by automatically disengaging the load. It applies power smoothly and automatically while the power source operates at an efficient speed; and once the load is accelerated, it transmits power at full efficiency.

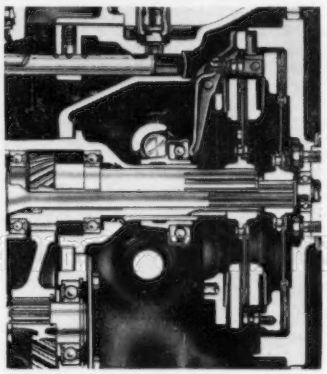
Farm Spraying Catalog

Spraying Systems Co., 3226 Randolph St., Bellwood, Ill., will send on request its new 20-page catalog No. 30, which includes illustrations, description and spraying data on all types of nozzles for boom, broadcast, hand and airplane spraying. Information on a wide range of accessory equipment is also included. Capacities of all types of nozzles are given in a reference form for all standard pressures and for all sizes of nozzles or orifices.

New 2-Stage Clutch

Dana Corp., Toledo 1, Ohio, has announced the production of a new Spicer two-stage clutch. This clutch enables the Two input shafts are used. This is accomplished by splining the secondary tubular hydraulic pump and PTO input shaft. The farmer to operate such machines as balers, mowers, corn pickers and forage harvesters continuously regardless of tractor starts and stops.

The clutch, operated by a single foot pedal, controls power into the tractor drive-wheels and to a live pump and PTO. The dual function clutch actuates both an 11-in primary and a 9-in secondary disk in turn. input shaft of the transmission passes through the hollow PTO shaft. Driving

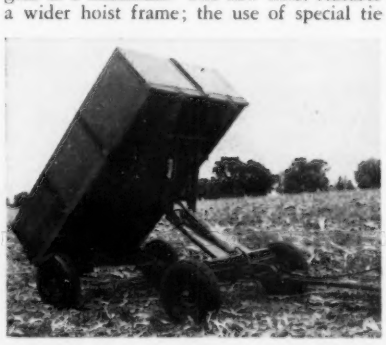


surface for the secondary disk is provided by a special flywheel ring.

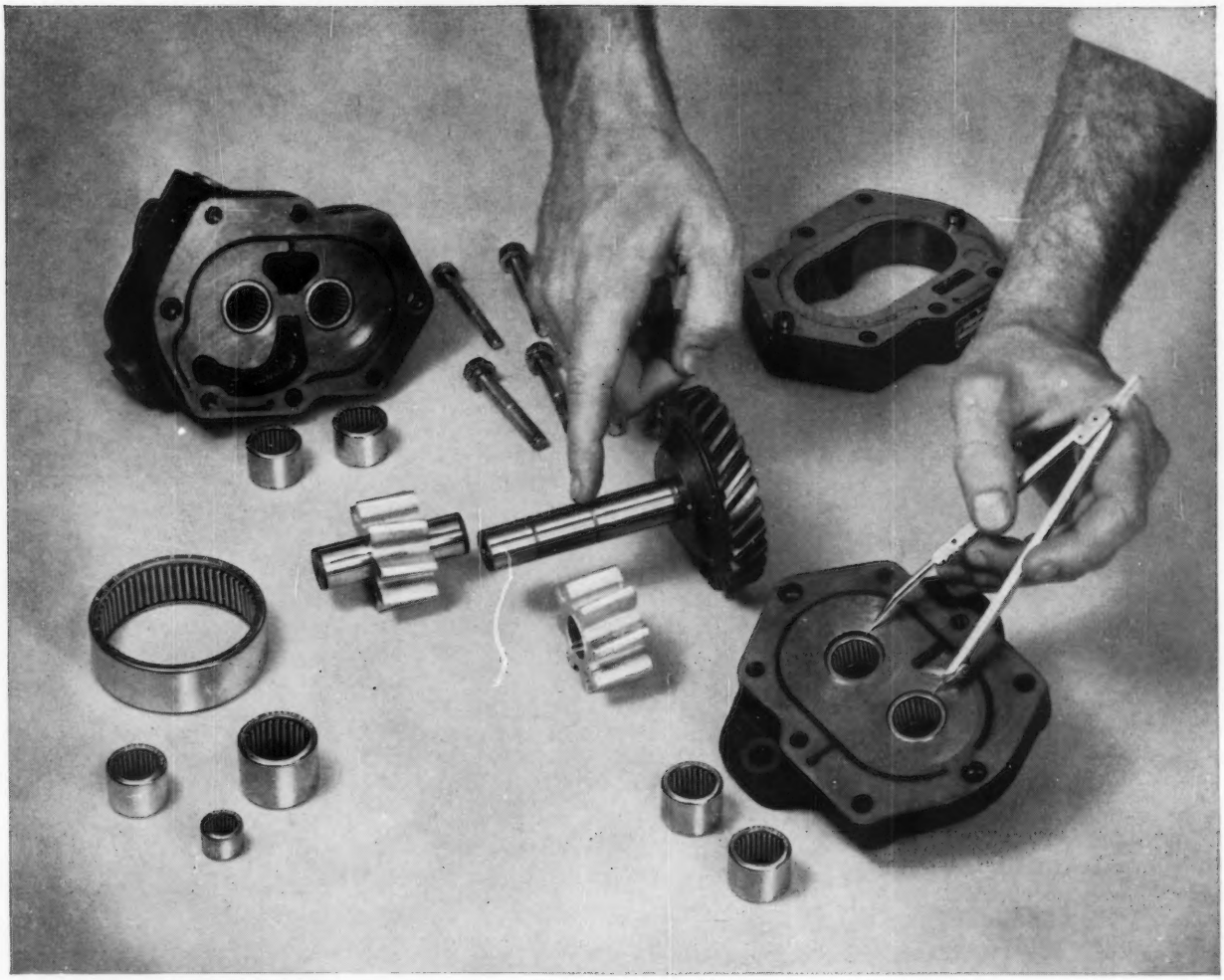
By pushing the clutch pedal part way down, through the light pressure range, the primary disk is disengaged, controlling the forward motion of the tractor. While travel is stopped, the operator can shift gears, but he has live PTO and pump. When the clutch pedal is pushed or depressed through its full range of travel, it disengages the secondary disk stopping the PTO and the hydraulic pump. A stop of simple design enables the operator to depress the clutch through its first stage but prevents disengaging the secondary disk and stopping the hydraulic pump and the PTO.

New Bolster Hoist

Lundell Manufacturing Co., Cherokee, Iowa, has developed a new wagon hoist designed to keep end pressure on the wagon gear at a minimum. The new hoist features a wider hoist frame; the use of special tie



rods to ease forward pressure on the bolster, and a lifting principle in which both cylinder ends work together in a pushing and pulling action to lift loads with low strain on the hoist frame. Hoists are easy to mount and available to fit all standard wagons.



Hydraulic Gear Pump—product of Webster Electric Company, Racine, Wis.

"You can use bigger shafts with TORRINGTON NEEDLE BEARINGS"

How to achieve a bearing assembly of minimum size while maintaining maximum shaft rigidity—that's a puzzler that many a design engineer has had to sweat out.

The Torrington Needle Bearing—because of its unique unit construction—has helped solve that problem in literally thousands of products throughout industry where it has become "standard equipment."

With its full complement of small diameter rollers, the Needle Bearing offers greater radial load capacity than any other anti-friction bearing of the same size. And because of its thin section, it permits the use of larger shafts to minimize deflection.

In addition, a Needle Bearing needs no inner race when running on a properly hardened shaft.

For twenty years our Engineering Department has helped designers and manufacturers to adapt the unique advantages of the Needle Bearing to their products. Let us help you with your anti-friction problems.

See our new Needle Bearing Catalog in the 1955 Sweet's Product Design File —or write direct for a catalog.

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Torrington, Conn. • South Bend 21, Ind.

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TORRINGTON *NEEDLE* **BEARINGS**

Needle • Spherical Roller • Tapered Roller • Cylindrical Roller • Ball • Needle Rollers

These features make the **TORRINGTON NEEDLE BEARING** *unique*

- low coefficient of starting and running friction
- full complement of rollers
- unequalled radial load capacity
- low unit cost
- long service life
- compactness and light weight
- runs directly on hardened shafts
- permits larger and stiffer shafts

A report to you about men and machines that help maintain International Harvester leadership

How IH engineers brought new ease of handling to the farm tractor field!

IH engineers didn't overlook the tractor driver in their search for greater farming efficiency. They talked to hundreds of operators . . . made studies like those that boost factory output . . . used scientific methods to measure operator fatigue and figure ways to reduce it. Out of this study came reach-easy controls, key starting, and many other advancements that make farming with a new McCormick® FARMALL® 300 or 400 tractor easier than most farmers ever thought possible.

INDEPENDENT PTO—the big, easy-to-reach pto lever starts or stops pto-machines *anytime*—with tractor moving or standing—to head off slugging.

Tip-toe pedal pressure sets double-disc brakes for fast, safe stops or pin-point turns.

FAST, SIMPLIFIED SHIFT—The "tall" gear-shift lever is close to the steering wheel. A neutral slot the full width of the shift pattern makes shifting easy.

ROAD-EASY STEERING—Big, 18-inch steering wheel lets operator's arms relax . . . teams with bearing-mounted worm and full gear to reduce steering effort.

TA—10 SPEEDS FORWARD—Just pull the handy TA lever for two speeds in each gear. This can save downshifting . . . speed farming . . . reduce operator fatigue.

INSTRUMENT PANEL—Read-easy gauges are grouped for a one-glance check-up. Ignition key, choke and light switch are at the operator's fingertips.

HYDRA-TOUCH — The operator just drops his right hand from the steering wheel onto hydraulic control levers which hold and return automatically.

DRIVER COMFORT—Foam-rubber cushion, hydraulic shock absorber, and variable-rate spring soak up jolts. Seat adjusts . . . tilts up for stand-up driving.

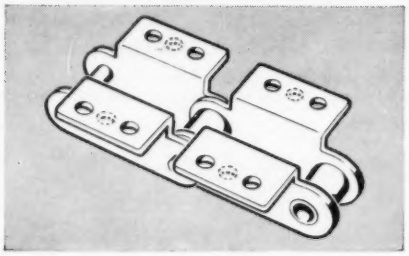
IH engineering teamwork has given new Farmall tractors comfort and convenience that improves operating efficiency. This typifies the way IH research, engineering, and manufacturing men pool their talents to make farming easier, and more profitable!

INTERNATIONAL HARVESTER

International Harvester products pay for themselves in use—McCormick Farm Equipment and Farmall Tractors . . . Motor Trucks . . . Crawler Tractors and Power Units—General Office, Chicago 1, Illinois.

Morse brings you a high-quality, low-cost Implement-Conveyor Roller Chain

Power Transmission and Conveyor Series chains. Inset shows B-1 and B-2 attachments.



Check the advantages of Morse Implement-Conveyor Roller Chain:

- √ Long service life
- √ Low cost
- √ Highly adaptable
- √ Require minimum maintenance
- √ Runs on American Standard sprockets
- √ Couples with standard double-pitch chain

Dependable, economical chain for farm implement, conveyor, and other slow-speed applications

Low-cost Morse Implement-Conveyor Roller Chains are light in weight and dependable; specially designed for farm implement, conveyor, and other slow-speed applications.

Morse Implement-Conveyor Chains are available in both Power Transmission and Conveyor Series. These chains are specially treated to offer durability, long life, and are adaptable to a wide range of farm machinery applications.

They operate on American Standard sprockets and will couple with equivalent standard double-pitch chain. Available with B-1 and B-2 (bent) attachments, made to American Standard Specifications. Designed for either or both sides, with one or two holes (see inset at left). Special attachments also designed for particular applications.

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Please send me Catalog Sheet CS 53-55 on Morse Implement-Conveyor Chain immediately.

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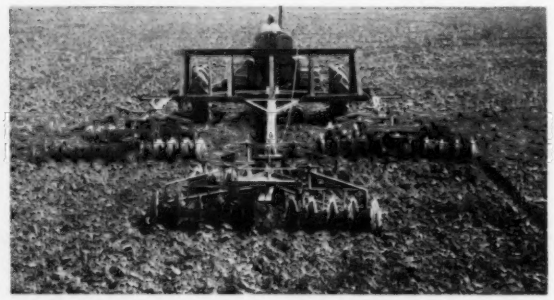
FARM POWER CONTRACTOR:
SPECIALIST IN FARMING EFFICIENCY

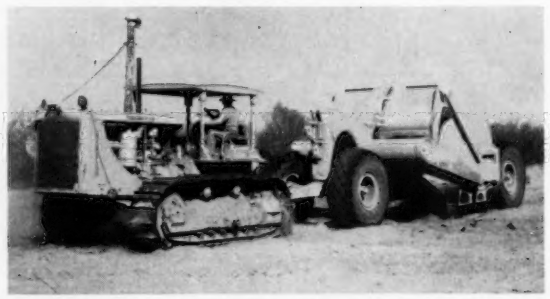
Modern farming frequently demands the specialized services and knowledge of a farm power contractor. Many successful farmers . . . both large and small . . . call on the farm power contractor equipped with Caterpillar machines to clear and form land, and to handle the heavy-duty tillage jobs as well. The result? They cut both operating costs and machinery investment. Illustrated here are just a few of the many jobs Caterpillar Diesel Tractors with matched heavy equipment do much more efficiently than ordinary farm tractors.

LAND CLEARING . . . Caterpillar Diesel Tractor equipped with a wide variety of equipment provides power, economy and efficiency to offer farmers low-cost clearing.

DEEP PLOWING . . . D8 pulls heavy-duty, roll-over plow going several feet deep. Deep tillage . . . another job done most profitably with Caterpillar Equipment.



SEEDBED PREPARATION . . . The CAT® D6 Tractor pulls three Rome disc plows. With big, economical Caterpillar Equipment, farm power contractors can often prepare land cheaper than a farmer will, using his own equipment.



LAND FORMING . . . D8 with No. 80 Cat Scraper leveling land. Tell farmers how they can gain the extra benefits from irrigation by forming their farms to table-top smoothness.

LAND SMOOTHING . . . Keeping leveled land smooth is the job for big equipment and economical power. This job fits the custom operator with Caterpillar Equipment to a "T".

For more information, check with your Caterpillar Dealer, or write us for free booklet, "Soil and Water Conservation", Dept. AE1155, Caterpillar Tractor Co., Peoria, Illinois, U.S.A.

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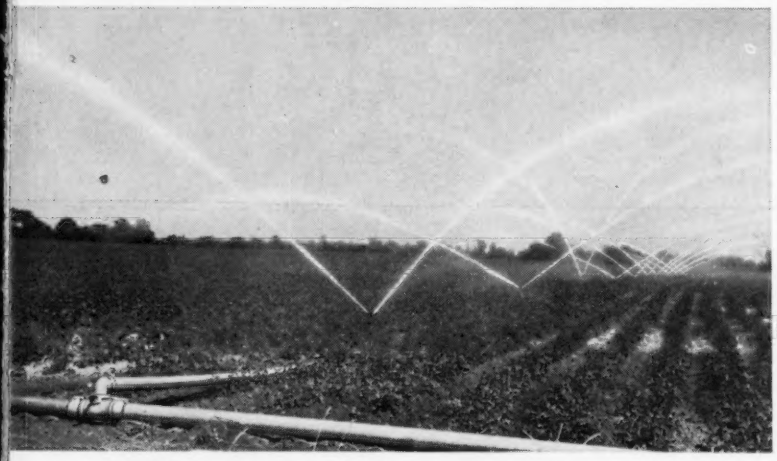
CHRYSLER-POWERED RAINMASTER PUMPER—



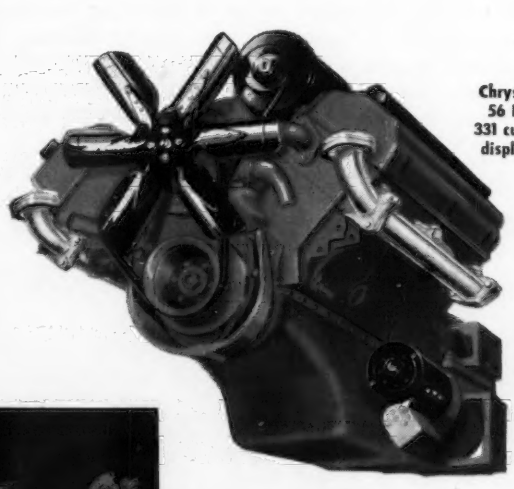
PHOTOS COURTESY CONSTRUCTION MACHINERY COMPANY, WATERLOO, IOWA

plus steady three-hour applications of water—

in three weeks produced big-money crop from total loss!

10 million gallons of water saves 200 acres of potatoes for Pennsylvania farmer

June 1955 found Stephen Kmecik and his son, farmers in East Springfield, Pennsylvania, facing loss of their entire 200-acre potato crop through lack of rain. Despite a great deal of cultivation, soil remained dry and pulverized, plants were dying. About the end of June the Kmeciks decided to irrigate and installed a CMC Rainmaster Pump, powered with Chrysler Ind. 56, 331 cubic inch displacement engine.



Chrysler Ind. 56 Engine—331 cubic inch displacement

Here in Stephen Kmecik's own words is the result: "We set the pump to pulling water out of Crooked Creek up 116 feet of grade and through a mile of pipe to the sprinklers. Each patch was given three hours of intensive spraying once a week for three weeks. After two applications the plants strengthened, took on new leaves and blossomed. Some plants didn't even come up until after irrigation. During the critical three weeks we figure each of our thirty-four sprinklers threw more than 300,000 gallons. Our decision to irrigate and our choice of a dependable pump, dependably powered has resulted in saving our entire crop."

Most irrigation pump manufacturers, like Construction Machinery Company, prefer powering with an engine users know and respect. That's why Chrysler powers more irrigation systems than any other engine. For information on irrigation engines—gasoline, natural gas or propane, 230 to 413 cubic inch displacement—see a Chrysler Industrial Engine Dealer, or write:

~~Dept. 000,~~ Industrial Engine Division, Chrysler Corporation, Trenton, Michigan. *Dept. 1711.*

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CHRYSLER
INDUSTRIAL ENGINES

INDUSTRIAL ENGINE DIVISION CHRYSLER CORPORATION

HOW TO BUY AGRICULTURAL BELTING

for SPECIAL EQUIPMENT DESIGN PROBLEMS

. . . and get "More Use per Dollar"

The success of a new farm equipment design frequently depends on the efficient operation of the belted drives that run its intricate mechanism.

Look for a company whose engineers will work with you to design a power transmission drive as nearly foolproof as possible for your equipment . . . a company with a reputation for designing and manufacturing rubber belts to meet the most exacting requirements of leading farm equipment manufacturers.

Specify by name the Agricultural Belts made by a company with long experience and specific technology in farm equipment . . . specify Manhattan Agricultural Belts.

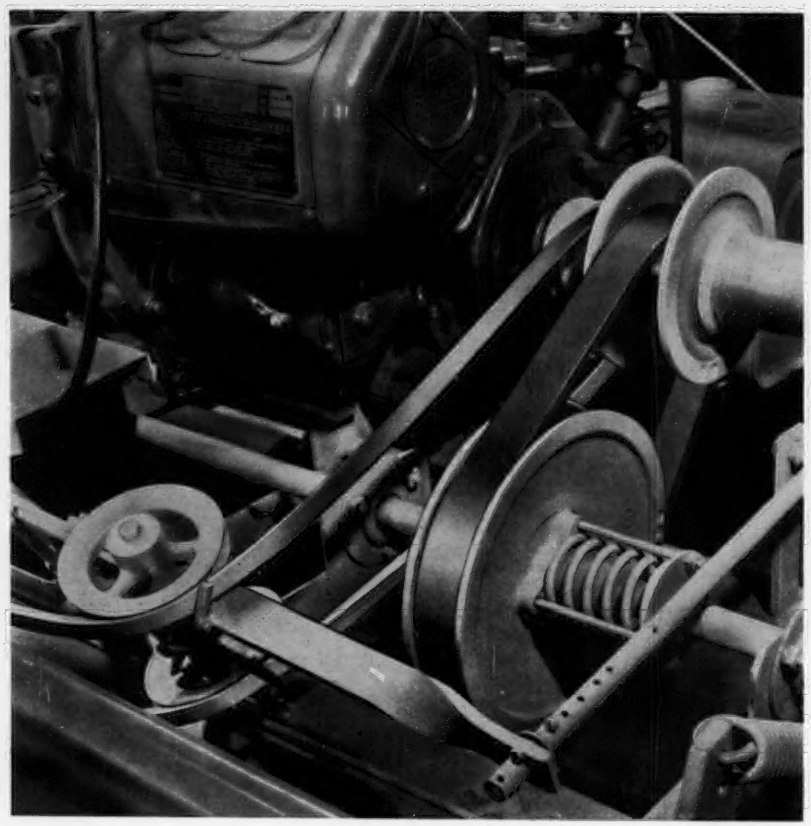

Photo courtesy Owatonna Manufacturing Co., Inc.

MANHATTAN AGRICULTURAL BELTS

At Manhattan, R/M engineers draw on more than 60 years of rubber technology and production experience to combine with the inventive genius of the equipment manufacturer to solve critical problems that may arise in the design of belted transmission drive problems. The variable speed drive for the center delivery self-propelled windrower shown above is a typical example. By working closely with the manufacturer, Manhattan engineers were able to assist in designing an efficient, dependable, trouble-free drive for this often difficult application. The engineered features of strength, flexibility and long-life built into the Manhattan Agricultural Belt designed for this drive helps account for its consistently uniform performance . . . its day-in, day-out dependability on the job. In all belted power applications, Manhattan Agricultural V-Belts, Condor Whipcord Endless Belts and Poly-V Drives are continually contributing to the success of new and existing farm equipment designs. Manhattan Agricultural Belts enable farm power equipment to perform at peak efficiency under all operating conditions and in all kinds of weather . . . thus furthering the good reputation of its manufacturer.

Let R/M engineers work with your engineering department to solve your belting problems. They can show you why Manhattan Agricultural Belts are the most reliable made today . . . how they add "More Use per Dollar" to the equipment they run.

RM-515

R/M

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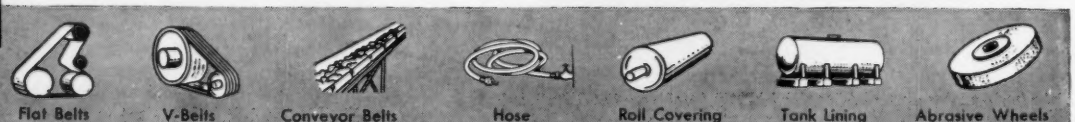

Other R/M products include: Industrial Rubber • Fan Belts • Radiator Hose • Brake Linings • Brake Blocks • Clutch Facings
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"I SAVE $2 A DAY

with my bulk milk handling system," says Kelsey H. Schilling, Middleport, N. Y.

Mr. Schilling figures that his Stainless Steel bulk milk tank will pay for itself in just 3 years. Handling costs are lower because it is easier to handle and ship milk. The pick-up truck driver loads and unloads the milk without any assistance, and hauls a larger "pay load" each trip.

Milk quality has shown improvement, too. After Mr. Schilling installed his 300-gallon Stainless Steel tank, the bacteria count dropped from 100,000 to less than *20,000*. Also, there is less stickage.

United States Steel has prepared an easy-to-read, informative booklet that tells all about the bulk milk handling system. Just send the coupon for your free copy.

See The United States Steel Hour. It's a full-hour TV program presented every other week by United States Steel. Consult your local newspaper for time and station.

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Please send me the free booklet on bulk milk handling equipment.

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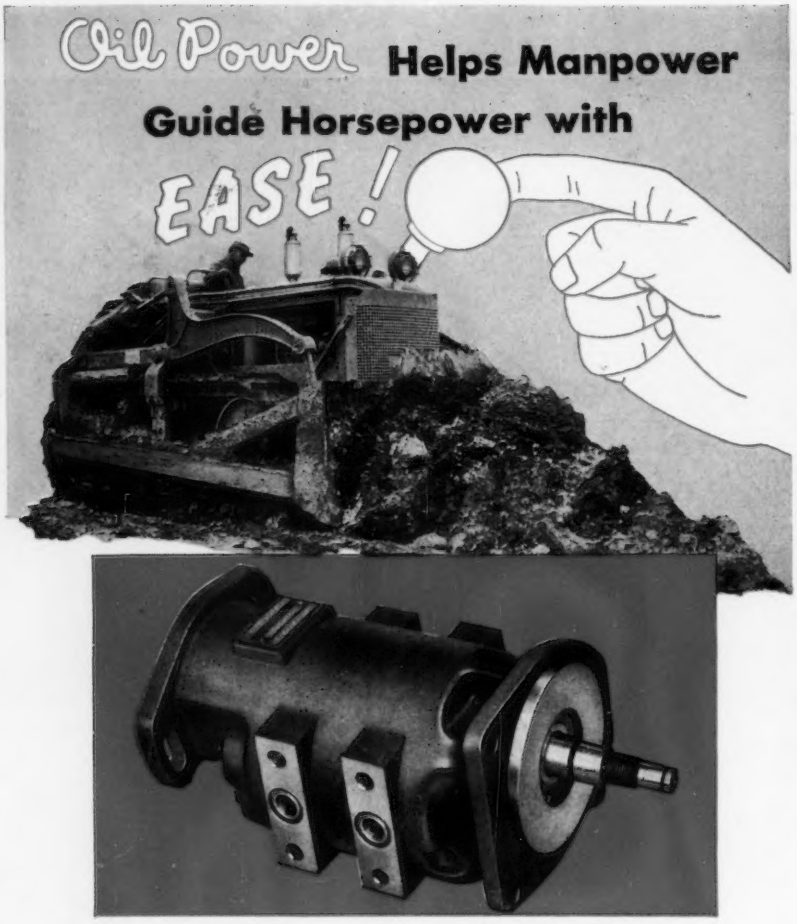
UNITED STATES STEEL



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Applicants for Membership

The following is a list of recent applicants for membership in the American Society of Agricultural Engineers. Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.

Ayers, A. Richard — Petroleum educational director, Illinois Farm Supply Co. (Mail) 448 N. Piatt St., Bement, Ill.

Braas, James E.—Sales representative, Warner Electric Brake & Clutch Co., 2325 W. Wells, Milwaukee, Wis.

Borsenik, Frank D. — Graduate student in agricultural engineering, Michigan State University, East Lansing, Mich.

Brabson, Thomas G.—Area representative, Appalachian Electric Power Co. (Mail) Box 383, Lebanon, Va.

Brikowski, Harold J.—On duty with U.S.-A.F. (Mail) 3801 Thaxton Ave. S.E., Albuquerque, N. M.

Brower, Frank R. Jr.—State conservation engineer (SCS), USDA. (Mail) 826 N. College St., Carlisle, Pa.

Burnett, John A., Jr.—On duty with U.S.A. (Mail) Alcatraz Island, Calif.

Clague, Thomas E.—Experimental engineer, John Deere Dubuque Tractor Works, Dubuque, Iowa. (Mail) 1922 Shiras

Copley, Geoffrey D.—Chief engineer, H. E. Robinson & Co. (Ja) Ltd., 81 Hanover St., Kingston, Jamaica, B.W.I.

Corwith, James, Jr. — Layout draftsman, product engineering dept., International Harvester Co., McCormick Works. (Mail) 2807 Harvey Ave., Berwyn, Ill.

Court, Kenneth — Assistant chief engineer, Vickers, Inc., 1400 Oakman Blvd., Detroit 32, Mich.

Crane, Jack W.—Graduate research assistant in agricultural engineering, Michigan State University, East Lansing, Mich. (Mail) 809 D Cherry Lane

Eberhardt, Charles J. — District agent, Martin Steel Products Corp. (Mail) Box 374, Enid, Okla.

Edwards, Florella L. — President, Edwards Equipment Co., 4312 Main St., Yakima, Wash.

Edwards, William D.—Sales representative, Groov-Pin Corp., 3687 Market St., St. Louis 10, Mo.

Fowler, John F.—Sales representative, Fleco Corp., Jacksonville, Fla. (Mail) 1393 Menna St.

Garrett, Donald M. — Student, California State Polytechnic College, San Luis Obispo, Calif. (Mail) 656 Caudill St.

Godwin, Guy M.—Co-owner, Godwin Tractor & Implement Co. (Mail) 3817 Clifton St., El Paso, Tex.

Gonzalez, Flavio R. — Agricultural engineer (SCS), USDA. (Mail) 404 Corpus St., Rio Grande City, Tex.

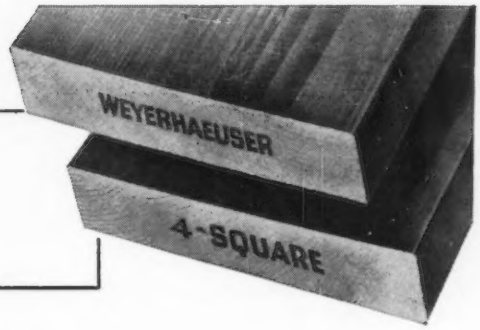
Gruber, Jonny J.—Graduate student in agricultural engineering, Utah State Agricultural College, Logan, Utah. (Mail) 150 N. 3rd, E.

Hakim, Azeem A. — Assistant professor in soil and water conservation, Indian Institute of Technology, Kharagpur (S. E. Rly.), India

Hansen, Lowell D.—On duty with U.S.A.F. (Mail) 506 S. Columbus, Yuma, Colo.

Harden, Eldon A.—Layout draftsman, farm implement div., International Harvester Co. (Mail) Box 6, Fairview, Ill.

(Continued on page 762)



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Pressure-Treated Lumber

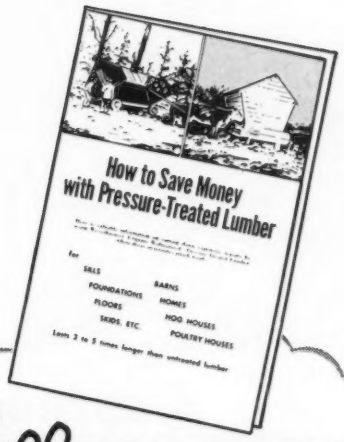
that reduces farm maintenance costs

Weyerhaeuser 4-Square Pressure-Treated Lumber will last 3 to 5 times longer in places where decay, dry rot or termites attack wood. Since termites are found in 47 states, and decay is a problem where wood is exposed to alternate extremes of wet and dry, pressure-treated lumber offers substantial savings, not only in replacement materials, but in time and money spent for making repairs.

Strong solutions of Wolman* preservative salts are forced into the lumber—standard treatment is three gallons of mixture for a 4″x 6″—6′ member. After kiln-drying, the salts remain in the wood to resist attack.

Weyerhaeuser 4-Square Pressure-Treated Lumber looks almost the same as ordinary lumber. It is clean, odorless, non-corrosive, and takes paint and glue very well. See it at the yard of your Weyerhaeuser 4-Square Lumber Dealer.

*Reg. U. S. Pat. Off.



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Applicants for Membership

(Continued from page 760)

Huntington, Leland W. — Production manager, Paradise Metal Industries, Paradise, Calif. (Mail) 1656 Nunnelly Rd.

Jordan, James A.—General salesman, International Harvester Co. (Mail) 313 N. Main St., North Brookfield, Mass.

Kinner, Richard L.—Rural sales representative, Western Massachusetts Electric Co., 45 Federal St., Greenfield, Mass.

Krizek, Joe F.—Agricultural engineer (SCS), USDA. (Mail) Box 607 Littlefield, Tex.

Laudencia, Pedro N. — Head, agricultural engineering dept., Central Luzon Agricultural College, Nueva Ecija, Philippines.

Locke, Thomas W.—Fieldman, Doane Agricultural Service, Inc. (Mail) 119 E. 1st St., Spencer, Iowa

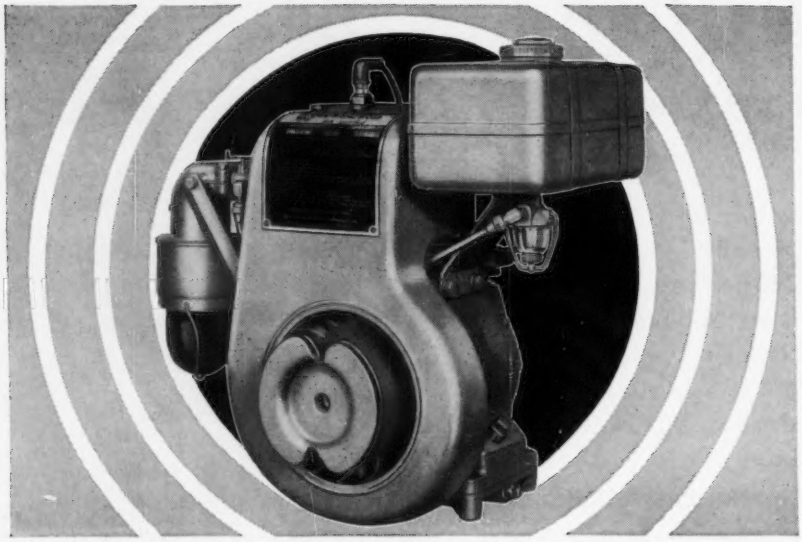
Lynch, Raymond J.—Co-ordinator, New Departure Div., General Motors Corp., Room 1162, 332 S. Michigan Ave., Chicago 4, Ill.

McGough, Herbert N. — Engineer, W. F. Covington Planter Co., Inc., PO Box 1249, Dothan, Ala.

Martin, Waldo D.—Design engineer, John Deere Wagon Works, Moline, Ill.

Meyer, Raymond J.—Engineer, engineering research div., John Deere Waterloo Tractor Works, Waterloo, Iowa

Mudge, Ceylon A.—Chief product engineer, Durkee-Atwood Co., 215 N.E. 7th St., Minneapolis 13, Minn.



Another NEW WISCONSIN Heavy-Duty Air-Cooled ENGINE

The Model BKN 3.2 to 6.8 H.P.

Brand new in design, this engine meets the increasing demand among original equipment manufacturers and engine power users for a compact, light weight, HEAVY-DUTY Air-Cooled Engine that offers a broad, flexible power range.

With a 17.8 cu. in. displacement, the new Model BKN delivers 6.8 hp. at its top speed of 3600 rpm., and 3.2 hp. at a minimum speed of 1600 rpm. Incorporated in this engine are all of the traditional Wisconsin Heavy-Duty features, including tapered roller bearings at *both* ends of the crankshaft; high tension rotary type *outside* magneto with Impulse Coupling; pump-circulated, constant-level splash lubrication system and efficient AIR-COOLING at all temperatures from sub-zero to 140° F.

For detailed specifications write for Bulletin S-183.

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World's Largest Builders of Heavy-Duty Air-Cooled Engines

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Nelson, Carroll H. — President and general manager, Nelson Manufacturing Co., 315 20th St., N. E., Cedar Rapids, Iowa

Nobrega, Nelson R.—Technical advisor to director, Distribuidora Vemag S. A., Sao Paulo, Brazil. (Mail) Alameda Rocha Azevedo, Nr. 1335

Pandya, Amarendra C.—Assistant professor in agricultural engineering, Indian Institute of Technology, Kharagpur (S. E. Rly.), India

Pevey, Will W.—Sales engineer, Dixie Irrigation Co., Inc. (Mail) PO Box 872, Greenwood, Miss.

Roberts, Maurice—Manager, Western Irrigation Co., Riverton, Wyo. (Mail) 316 S. 7th St.

Salmon, Willard E.—Agricultural sales engineer, Pacific Power and Light Co., 236 Lyons St., Albany, Ore.

Shambaugh, Theodore J. Jr.—Agricultural equipment advisor. (Mail) USOM/Lebanon, c/o American Embassy, Beirut, Lebanon, Dept. of State, Washington 25, D. C.

Simonsen, Merle W. — Partner, Simonsen Mill Rendering Plant, Quimby, Iowa

Singh, Kynpham—Graduate student in agricultural engineering, Iowa State College, Ames, Iowa. (Mail) 325 S. Wilmoth Ave.

Smith, Gordon H.—Construction and design engineer, Tripp Ditch Line & Construction Co., Fort Stockton, Tex. (Mail) 1202 N. Colpitts

Stables, David C. Jr.—Rural engineer, Virginia Electric & Power Co., Petersburg, Va.

Stockman, James E. Jr. — On duty with armed services. (Mail) 2131 Crystal Springs Ave., Roanoke, Va.

Sutton, W. B.—Owner, Carolina Tractors, Inc. (Mail) Faison, N. C.

Thomas, Jeffrey J.—Assistant professor in agricultural engineering, University of British Columbia, Vancouver 8, B. C., Canada

Virdi, Sher S.—Student in agricultural engineering, Alabama Polytechnic Institute, Auburn, Ala. (Mail) 1131 Magnolia Hall

Walters, Franklin C.—Project engineer, engineering research div., John Deere Waterloo Tractor Works, Waterloo, Iowa. (Mail) 1274 W. Mullan St.

Wellborn, Earl E.—Junior engineer, research development dept., John Deere Waterloo Tractor Works, Waterloo, Iowa. (Mail) 1176 Mitchell Ave.

Transfer of Membership Grade

Anderson, Donald A. — Senior engineer, J. I. Case Co., Racine, Wis. (Mail) 5111 Erie St. (Affiliate to Member)

Hewitt, William A. — President, Deere & Co., Moline, Ill. (Affiliate to Member)

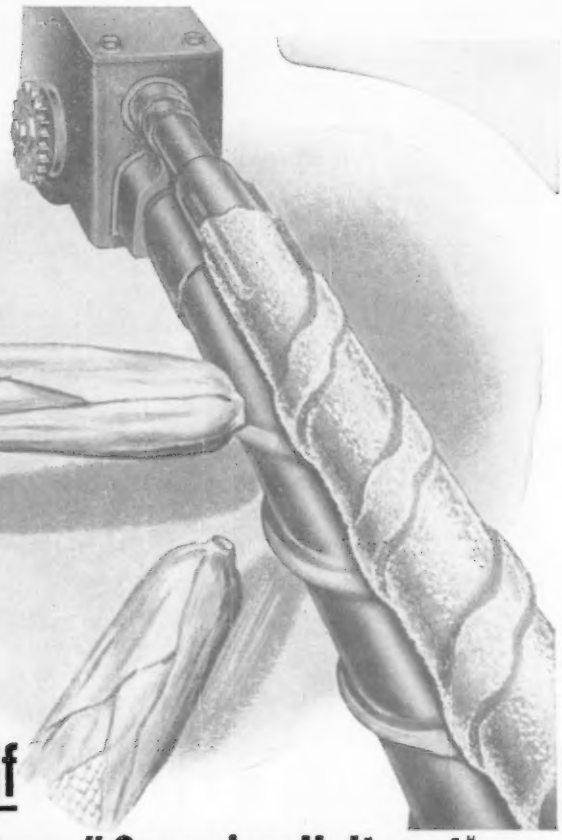
Opper, Lincoln I.—V-Belt engineer, belt engineering dept., The Dayton Rubber Co., Dayton, Ohio. (Affiliate to Member)

Phillips, Ross A. — Assistant professor in agricultural engineering, West Virginia University, Morgantown, W. Va. (Associate Member to Member)

Puckett, Hoyle B. — Agricultural engineer (AERB), USDA. (Mail) Agricultural Engineering Dept., University of Illinois, Urbana, Ill. (Associate Member to Member)

Splinter, William E.—Research associate professor in agricultural engineering, North Carolina State College, Raleigh, N. C. (Associate Member to Member)

Picking Magic



Shelled corn losses are cut in half

...with the "Corn Saver" Snapping Unit on the NEW FORD MOUNTED CORN PICKERS

A glance at the snapping rolls above reveals a new, advanced concept of corn harvesting efficiency.

Notice, for example, how the ears of corn drop off to the side, rather than riding on the rolls where wasteful shelling occurs. Notice, too, the smaller diameter of the rolls. This reduces wasteful butt-shelling. And although these snapping rolls are smaller in diameter, their sure-grip action reduces clogging.

In numerous field tests, the new Ford Mounted Corn Pickers have reduced shelled corn losses fully 50 percent. In addition, bothersome and dangerous stalk clogging has been minimized.

The combination of this new picker and one of Ford's famous Tricycle Tractors makes a harvesting unit that's unmatched for performance. It's another example of Ford's contribution of better machines for better farming. Tractor and Implement Division, Ford Motor Company, Birmingham, Michigan.

Ford Farming

GETS MORE DONE... AT LOWER COST

NEW BOOKS

Atomic Energy Research at Harwell by K. E. B. Jay. Cloth, xxi+144 pages, 5½ x 8½ inches. Illustrated. Philosophical Library, Inc., 15 E. 40th St., New York 16, N. Y. $4.75.

This book from the United Kingdom Atomic Energy Authority describes work done at Harwell, an atomic energy research establishment, between years 1951 and 1954.

Jet Engine Manual by E. Mangham and A. Peace. Cloth, 133 pages, 4 x 6½ inches. Illustrated and indexed. Philosophical Library, Inc., 15 E. 40th St., New York 16, N. Y. $3.75.

This book is a handy up-to-date reference for those concerned with the operation and maintenance of turbine aero-engines.

Diesel Engine Principles and Practice by C. C. Pounder. Cloth, xii + 848 pages, 5½ x 8½ inches. Illustrated and indexed. Philosophical Library, Inc., 15 E. 40th St., New York 16, N. Y. $17.50.

This volume is a comprehensive reference book, arranged in 26 sections, covering theory, construction and applications of diesel engines of all types. It has 580 illustrations and 112 tables.

Metallurgical Progress—2, a second series of critical reviews, reprinted from *Iron & Steel*. Cloth, 72 pages, 8½ x 11 inches, Philosophical Library, Inc., 15 E. 40th St., New York 16, N. Y. $6.00.

The book contains research work reviews in the following fields: Preparation of ores by J. M. McLeod; electric steel production by D. D. Howat; and non-metallic inclusions by H. B. Bell.

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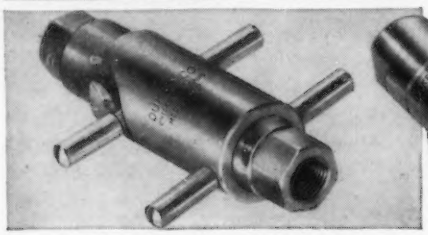
DUKES New Hydraulic
BREAK AWAY
SELF-SEALING
COUPLERS

DUKES BREAK-AWAY COUPLER
Model 112 KS

Here's a break-away coupler that *does* couple with full pressure on both sides of the line.

- POSITIVE BREAK-AWAY ACTION
- POSITIVE SELF-SEALING
- NYLON VALVE SEATS
- SELF ALIGNING
- CAN BE MOUNTED *INDIVIDUALLY* OR IN *TANDEM*
- DESIGNED TO MEET EQUIPMENT MANUFACTURER'S REQUIREMENTS
- BUILT TO WITHSTAND HARD USAGE



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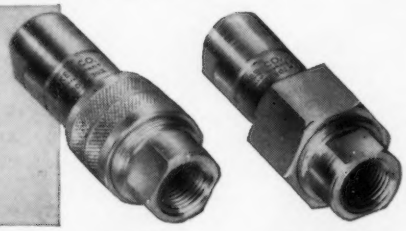
IN LINE BREAK-AWAY COUPLER

No mounting brackets needed. Special *patented* compensating chamber allows recoupling by hand under full line pressure. Nylon valve seats assure positive sealing.



Model 302 KNURLED SLEEVE
Model 302-H HEX SLEEVE
DUKES IN LINE QUICK COUPLERS

For mounted equipment. Simplicity of design yet rugged construction assures satisfaction and ease of continuous operation. Nylon valve seats. Include all of above features except break-away action.

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"Member of the National Fluid Power Association"

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PERSONNEL SERVICE BULLETIN

NOTE: In this bulletin the following listings current and previously reported are not repeated in detail; for further information see the issue of AGRICULTURAL ENGINEERING indicated.

POSITIONS OPEN—APRIL—O-125-718. MAY—O-180-724, 214-727, 214-728. JUNE—O-248-733. JULY—O-289-735, 307-739, 316-740. AUGUST—O-305-741, 325-743, 324-745, 334-746, 338-747, 345-748, 346-749, 346-750, 347-751, 350-752. SEPTEMBER — O-331-754, 363-755, 335-756, 352-758, 372-759, 384-760. OCTOBER—O-401-761, 402-762, 402-763, 404-764, 405-765, 409-766, 409-767, 409-768, 407-769, 407-770, 407-771, 413-772, 415-773, 394-774.

POSITIONS WANTED — JUNE—W-203-25, 247-27, 252-29, 263-31. JULY—W-266-35. AUGUST — 312-40. SEPTEMBER — W-351-41. OCTOBER—W-383-43, 391-44, 398-45, 388-46, 375-47, 420-48.

NEW POSITIONS OPEN

AGRICULTURAL ENGINEERS (several) for product research, design, and development on farm implements, farm tractors, industrial power tractors and road building equipment, including work in design analysis, stress analysis and laboratory and field testing, with major broad line manufacturer. Locations in Midwest. Age 24-40. BS or MS deg in agricultural or mechanical engineering, or MS in electrical engineering, with mathematics through calculus, and machine design courses. Farm background, design and test experience desirable but not essential. Must be able to work with others and have desire to work with farm implements and tractors. Opportunity in several engineering groups for individual to go as far as ability and ambition will carry him. Salary open, depending on qualifications and experience. O-385-775

METALLURGIST to handle chemical analysis of steels; physical, salt spray, and other tests on metal products. Midwest. Age 30-40. College degree with engineering background. Several years experience with manufacturer or laboratory. Salary open, depending on qualifications and experience. O-430-776

AGRICULTURAL ENGINEER for research in rural electrification in a north central state. Work is in agricultural engineering department of a land grant university, in project sponsored by electric power suppliers to rural customers. Some extension activity. BS deg in agricultural engineering, or equivalent. Experience in rural electrification preferred, but not an absolute requirement. Must have initiative, imagination and ability to cooperate and get along well with others. Good opportunity in new program with possibilities of development. Salary open. Starting salary will depend on educational background and experience. O-439-777

AGRICULTURAL ENGINEER for research in the use of electricity on farms with a Midwest land grant university. Work will involve cooperation with power suppliers on tests and utilization of electricity on farms. BS deg in agricultural engineering desirable, as well as experience in the field of rural electrification. Salary $5400-$7200, depending on qualifications. O-446-778

ASSISTANT CURATORS (2) for Henry Ford Museum and Greenfield Village, with curatorial responsibility for collections in agriculture, transportation, communication or power; close cooperation with department of education; and supervision of required restorations. BS deg in agricultural, mechanical, or electrical engineering. Graduate work in history desirable. Several years museum experience, technical editing, teaching or research. Work permits time for study for higher degrees at universities in the vicinity. Salary open. O-451-779.

AGRICULTURAL ENGINEER (instructor or assistant professor rating), to teach service and professional courses in farm power and machinery, at a land grant university in the South. Age 25-35. BS and MS deg in engineering. Must be of good character and like to work with students. Excellent opportunity for advancement. Salary, $4000 on 9-mo basis or $5000 on 12-mo basis, depending on training, and experience. O-453-780.

AGRICULTURAL ENGINEER (assistant rating) for research in crop conditioning and grain storage at branch experiment station in a southern state. Age 22-30. BS and MS deg in agricultural engineering. Must be willing to work and able to get along with people. Two-year job with opportunity to earn consideration for more advanced work in same state. Salary $3,600, 12-mo basis, 30 days annual leave. O-453-781

(Continued on page 766)

DURKEE-ATWOOD
V-BELT QUIZ
for Design ENGINEERS

DO YOU KNOW HOW TO MAKE V-BELTS LAST LONGER?

Take an extra minute to follow the proper steps in installing belts and performance time can be increased by many years. 1. Loosen motor or driven unit. 2. Install belts. 3. Tighten drive. 4. Check alignment of sheaves. 5. Make sure shafts are parallel. 6. Adjust tension again after 24 hours operation. (Sales plug: Ask your D-A distributor for more tips on getting better production and longer life from your V-drives).

FREE COPY! *Handy Tips on V-belts and V-drives*

See your D-A distributor or write Dept. AE-11 for catalog that includes conversion tables, engineering data, latest Rubber Manufacturers Association horsepower ratings, drive selections and helpful Do's and Don'ts of V-belt operation.

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DURKEE-ATWOOD CO.
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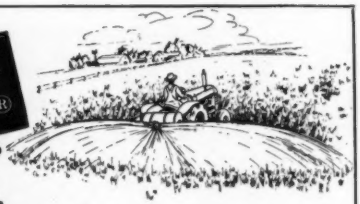
BoomJet®
SPRAY NOZZLES



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up to 66 feet WIDE with one compact assembly

for the broadcast spraying of grains, grasses and liquid fertilizers

Easily mounted on rear of tractor. Use where spray boom accuracy is not needed. Sprays to both sides in field spraying or one side only in fence row or road side spraying. A Spraying Systems Co. **original design.** Made in all brass for general farm spraying and in all aluminum for spraying liquid fertilizers. For complete information write for Bulletin 66.

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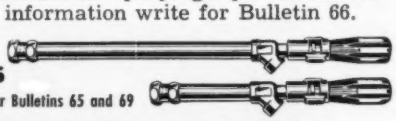
All capacities. Write for Bulletins 65 and 69



For TeeJet SPRAY NOZZLES . . . write for Bulletin 58

SPRAYING SYSTEMS CO. 3226 Randolph Street Bellwood • Illinois

336,999 miles of extrusions!

Our extruders have turned out enough plastic and rubber extrusions to reach to the moon and halfway back. In compiling this vast experience General Tire's Industrial Products Division has supplied thousands of original equipment manufacturers with just about every known type of extrusion. No job is too large, too small or too complicated for our design and production staff. Perhaps *you* can benefit from the fantastic extrusion mileage we've accumulated down through the years.

For literature or further information write to The General Tire & Rubber Company, Wabash, Indiana, Department F.

"From Plans to Products in Plastics and Rubber"

THE GENERAL TIRE
Industrial Products Division
WABASH INDIANA

Personnel Service Bulletin

(Continued from page 764)

AGRICULTURAL ENGINEER, for sales representative with manufacturer of farm water systems. Territory in Kansas, Oklahoma and Western half of Missouri. Immediate opening. Car furnished. Salary commensurate with ability and experience. Full traveling expenses and bonus. O-454-782

AGRICULTURAL ENGINEER for farm electrification work in a midwestern private utility. Age, under 30. BS deg in agricultural engineering, or equivalent. Responsible for carrying out farm electrification program in rural territory of company. Salary open. O-448-783

AGRICULTURAL ENGINEER (assistant professor rank) for research in mechanization of cranberry production in experiment station associated with an eastern land grant university. Age 25-35, approximate. BS deg in engineering from recognized school, and MS deg or 3 yr of responsible engineering experience in farm machinery field. Interest and ability in research applied to problems of agricultural production. Excellent opportunity to show imagination, drive, and ingenuity. Classified position with fixed annual increases. Starting salary $5220. O-463-784

AGRICULTURAL ENGINEER (instructor rank) for research in mechanical requirements of quality forage production, in an eastern land grant university. Age 23-30. BS deg in engineering from a recognized school. Advanced degree or experience in engineering work desirable. Interest and ability in research to help farmers and consumers. Excellent opportunity to show imagination, drive, and ingenuity. Classified position with fixed salary and annual increases. Starting salary $4,440. O-463-785

NEW POSITIONS WANTED

FARM CROPS PROCESSING SPECIALIST for extension, teaching, research, sales or service with industry or public service, anywhere in USA. Single. Age 27. No disability. BS deg in mechanized agriculture, 1954. MS deg in farm crops expected 1956. Research fellow, agricultural engineering department, Rutgers University. Farm background. Some experience in crop conditioning, drying, grain storage, moisture meters and applications of plastics. Post-war enlisted and non-commissioned service in US Air Force, administration section, 3 yr. Available Feb. 15. Salary $4400-4800. W-412-49

AGRICULTURAL ENGINEER for design, development, research, extension or teaching in power and machinery or soil and water field, with industry or public service, preferably in West. Married. Age 28. Limited vision in right eye. BS deg in agricultural engineering, 1952, MS deg in irrigation and drainage, 1955, Utah State Agricultural College. Part-time work with US Geological Survey while working on BS deg. Part time work with US Bureau of Reclamation while working on MS deg. Farm background. War enlisted service in Signal Corps nearly 2 yr. Available Feb. 1956. Salary $4800. W-428-50

POWER AND MACHINERY MAN for development or research with public agency or with manufacturer, distributor or farming operation in West, Southwest or foreign location. Married. Age 45. No disability. BS deg in agricultural engineering, 1953, California State Polytechnic College. Farm background. Experience in diesel engine and tractor manufacture, 8 yr; operating engineer, municipal diesel power plant, 5 yr; harvesting superintendent on sugar plantation nearly 2 yr. War enlisted service in Navy in charge of portable diesel electric generators and acting chief engineer of ship. Available now. Salary open. W-429-51

SOIL AND WATER MAN for design, development, research, extension, teaching, sales or service with industry or public service. USA or foreign. Limited travel. Married. Age 27. No disability. BS deg in agriculture, Feb. 1952; one year graduate study, University of Florida. Farm background, including management experience. Since June 1954 with tire and rubber company in budget, credit and sales. Post-war enlisted service in Army Transportation Corps, 1½ yr. Available on 30-day notice. Salary open. W-445-52

AGRICULTURAL ENGINEER for design or field work and inspection in soil and water field, preferably with consulting engineer in West. Single. Age 24. No disability. BS degs in agricultural and civil engineering. Two summers work experience with consulting engineers. Post-war commissioned service, Artillery. Available January 5, 1956. Salary open. W-429-53

POWER AND MACHINERY and farm shop work teacher, some research experience, for extension, teaching, or research with public service, anywhere in USA. Married. Age 37. No disability. BS deg in agriculture with major in agronomy and farm machinery, Texas Technological College, 1952; 10 hr toward MS deg. Farm background. Research in grain drying, 1953-55 for Texas Agricultural Experiment Station. Taught farm shop, wood and metal work, agricultural surveying, terracing, irrigation, farm buildings, advanced shop, and shop teaching methods, 1952-55. War enlisted and commissioned service over 5 yr. Available on reasonable notice. Salary open. W-422-54.

AGRICULTURAL ENGINEER for extension, service, or writing in soil and water field with public agency, consultant or farming operation, preferably in Southwest, West, or Hawaii. Married. Age 30. No disability. BS deg in agricultural engineering, 1949, Iowa State College. Self-employed grain and livestock farmer. War enlisted and cadet service in Navy. Available March 1, 1956. Salary open. W-449-55

NEW BULLETINS

NIAE Bulletins. The following bulletins have been received recently from the National Institute of Agricultural Engineering, Wrest Park, Silsoe, Bedfordshire, England:

Some Physical Properties of the NIAE Tractor Test Tracks—Report No. 50.

The Effect of Bruising and Crushing on the Drying Rate of Grass and Lucerne—Report No. 52.

Farm Ponds for Household Water Supply by C. V. Phagan and E. R. Daniel. Oklahoma A. & M. College (Stillwater) Agricultural Extension Service Circular 580. The 16-page, illustrated circular contains plans and specifications for locating and constructing several types of pond water systems. Information is based on work being done by the Oklahoma Agricultural Experiment Station in a study of equipment and methods for treating pond water to insure its purity and clarity.

KOHLER ENGINES
4-CYCLE • AIR-COOLED

A Quality Engine for Quality Equipment

Short Stroke
- Less Friction and Wear
- More Power
- Longer Life

Easy Starting

K90...2.5 to 3.6 H.P.
K160..3.6 to 6.6 H.P.
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PLUMBING FIXTURES • HEATING EQUIPMENT • ELECTRIC PLANTS
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Know How and RESPONSIBILITY are behind "WHEELS by F&H

Our constant search for wheel improvement takes ALL factors into account—

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BURLAP BULLETIN

News about packaging and agricultural and industrial developments in burlap

ANY OF THIS MATERIAL MAY BE REPRODUCED WITHOUT PERMISSION.

French Hail Test Shipment of Raw Cotton

Industry Praises Burlap Program

A test shipment of raw cotton in newly developed burlap coverings has arrived in excellent condition at Le Havre, France from Beaumont, Texas. A second test shipment to domestic mills has met with equal success.

The standard practice has been to cover ⅔ of the cotton bale, the unprotected portion picking up grease, oil, tar, etc.—a costly practice at today's high cotton prices. Now the entire bale is being covered with heavy-duty, economical burlap.

As a result of success in these preliminary tests, further test shipments of 2,000 bales are now under way. Several different types of burlap covers are being tested to find the one best suited. The tests are being conducted jointly by the National Cotton Council and the Burlap Council with the cooperation of a large number of cotton shippers and mills.

Bulldog strength
Unmatched toughness
Rugged performance
Low cost
Adaptability
Plentiful supply

That's the way to spell agriculture's toughest, most versatile textile.

"Miss Florida" Wins Beauty Contest

The delicately-skinned white Sebago in the new lightweight 50 lb. potato sack won the applause of bag manufacturers, importers and chain store buyers recently at the Grand Union warehouse at Carlstadt, New Jersey. They had assembled to judge a test shipment of potatoes in the new lightweight potato bags with which the Burlap Council has been experimenting.

In this shipment from Hastings, Florida several different weights of fabrics were used and the judges gave top score to the 6 oz. 7 x 8 fabric on a price basis and the 6½ oz. 8 x 8 cloth on a quality basis. A luncheon followed the inspection. The tests proved that the lightweight fabrics are strong enough in a 50 lb. bag to assure protection of the potato in transit.

The more inexpensive fabric lowers the margin between burlap and paper to 1 to 2 cents per bag not considering resale value. Representatives of used bag dealers who were present forecast a 2 to 3 cent salvage value.

Export Duties Removed

The Indian Government has removed all export duties on jute fabrics, and burlap prices have declined to prewar levels. In terms of today's depreciated dollar, prices are now lower than they have been in 25 years.

What Can Burlap Do For You?

Write to William A. Nugent, Vice President, The Burlap Council, 155 East 44th Street, New York 17, about the projects you are interested in. With its many weights and constructions, this versatile fabric should be investigated for many uses where it can save money at its new low price *and do the tough jobs.*

Published by The Burlap Council of the Indian Jute Mills Association
155 East 44th Street, New York 17, N. Y.

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St. Joseph, Michigan

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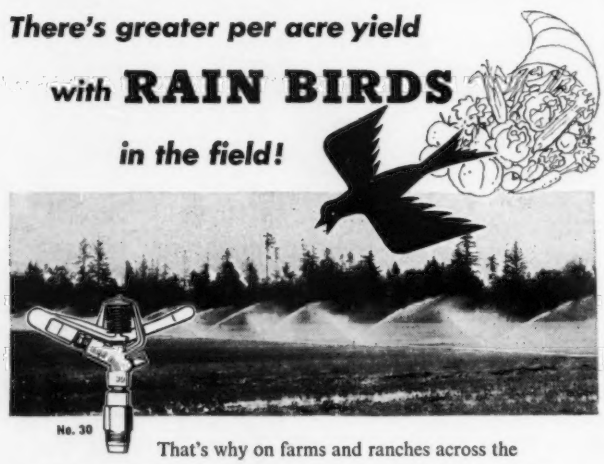
***with* RAIN BIRDS**
in the field!



That's why on farms and ranches across the nation . . . around the world, you'll find more RAIN BIRDS than any other type sprinkler.

Made with a minimum of moving parts to wear or require servicing, RAIN BIRDS stay on the job, performing day in and day out with maximum efficiency and dependability.

Remember, if it hasn't the name . . . it isn't the same. Specify RAIN BIRD!

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Who Should Join ASAE

If any one of the following descriptions covers your present work:

- Development, design, and application of farm tractors and implements and their components
- Design and improvement of farm buildings
- Engineered improvements for soil and water conservation and use
- Creating applications for electricity in farm practice and living—

then you can derive much benefit from membership in ASAE, and the Society cordially invites you to make application. For further information write

AMERICAN SOCIETY OF AGRICULTURAL ENGINEERS
St. Joseph, Michigan

FACTS

about

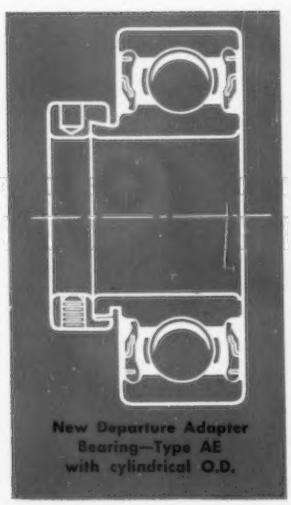
NEW DEPARTURE
BALL BEARINGS

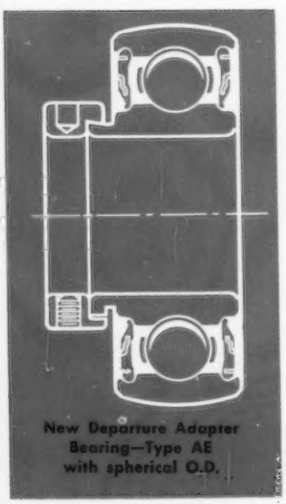
Adapter bearings for fast, easy mountings at low cost!

New Departure adapter ball bearings provide inexpensive mountings for many applications.

They are precision bearings, pre-lubricated and efficiently sealed. Also available with stamped flanges, these bearings become complete, initially aligned units for quick assembly.

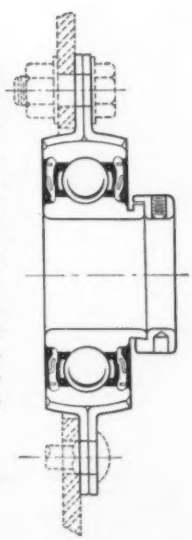
Designed for moderate loads and speeds and for applications where alignment and concentricity are not critical, the bearings eliminate need for shaft shoulders, ground bearing seats or press fits. The eccentric cam has a self-locking action when tightened against rotation and is intended for uni-directional rotation. New, highly efficient Sentri-Seals give the bearings optimum protection against dirt . . . longer life without attention.


New Departure Adapter Bearing—Type AE with cylindrical O.D.


New Departure Adapter Bearing—Type AE with spherical O.D.

TYPICAL APPLICATION OF NEW DEPARTURE ADAPTER BEARINGS

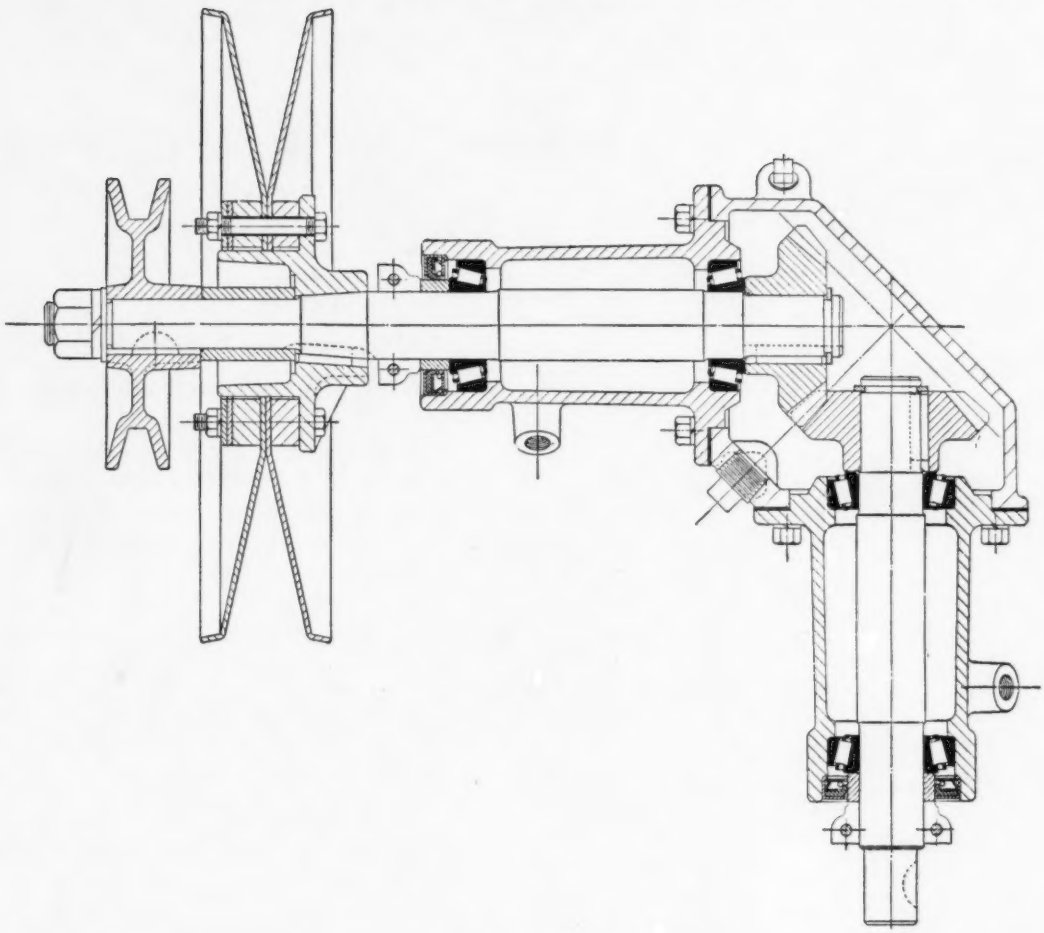
New Departure adapter bearings — Type AE — may be used to especial advantage on farm implements and machines operating at moderate speeds. Bearings with loosely assembled flanges are slipped on the shaft and lightly bolted to side plates. After flanges are finally secured, locking collars are tightened in direction opposite rotation and fixed by set screw. Dimensions and load ratings of various adapter bearings are listed in the latest New Departure catalog.



WRITE FOR NEW CATALOG
23rd EDITION

NEW DEPARTURE • DIVISION OF GENERAL MOTORS • BRISTOL, CONN.

How Allis-Chalmers Handles Heavy Combination Loads in a Harvester Drive



IN this Allis-Chalmers harvester the drive comes from the main harvester through the vertical shaft and goes out the horizontal shaft to drive the cylinder and the header through the V-belts.

One of the problems for Allis-Chalmers engineers was mounting the gear shafts. They turn at fairly high speeds, 750 rpm, and the loads are heavy enough to make ordinary bearings fail in a short time.

To meet these conditions, Allis-Chalmers mounted the shafts on Timken® tapered roller bearings. The bevel gears develop heavy thrust loads as well as radial loads. Timken bearings take these combination loads because of their tapered design. No additional thrust devices are required. Timken bearings hold the gears in accurate alignment which reduces gear wear, forestalls trouble.

These gears run in a bath of oil, so good bearing closures are especially important. Timken bearings hold the shafts concentric in their housing; this makes for more effective closures. Oil can't leak out or dirt get in.

Dirt and combination loads are two important problems Timken bearings help solve. A third: ease of operation. Timken bearings cut friction to a minimum, make equipment run smoother and last longer.

Do you have our helpful booklet "Tapered Roller Bearing Practice in Current Farm Machinery Applications"? Write for a free copy. The Timken Roller Bearing Company, Canton 6, Ohio. Cable address: "TIMROSCO".

The farmer's assurance of better design

Tapered Roller TIMKEN BEARING EQUIPPED

NOT JUST A BALL ◯ NOT JUST A ROLLER ⬭ THE TIMKEN TAPERED ROLLER ⬭ BEARING TAKES RADIAL ⓪ AND THRUST →⓪← LOADS OR ANY COMBINATION →✳←